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AIR QUALITY TECHNICAL REPORT

NOVEMBER 1983

PREPARED BY:
AEROCOMP, INC.
FOR:

DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

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AIR QUALITY ANALYSIS FOR THE COMBINED HYDROCARBON EIS, EASTERN AND SOUTH-CENTRAL UTAH -- SUNNYSIDE STSA

VOLUME I

Aerocomp Document 33TR03

Submitted to:

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Bureau of Land Management
Utah State Office
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EXECUTIVE SUMMARY

This document was prepared in support of the Sunnyside Combined Hydrocarbon Lease Conversion Environmental Impact Statement (EIS). The EIS is being prepared by the Bureau of Land Management (BLM), and was initiated by lease conversion applications filed by proponents of five tar sand projects within the Sunnyside Special Tar Sand Area (STSA). Facilities have been proposed by Amoco Production Company, Chevron USA Inc., Enercor, Mono Power Company, and Sabine Production Company. Under the Combined Hydrocarbon Leasing Act of 1981, the proponents have requested conversion of existing oil and gas leases to combined hydrocarbon leases.

Encompassing 157,445 acres, the proposed lease conversion area is located in the State of Utah -- northeastern Carbon and southern Duchesne counties. Aerocomp, Inc. was instructed by the BLM to prepare an air quality impact assessment associated with the proposed facilities. Emissions into the atmosphere are expected to result from mining, transportation, and processing of the tar sand material. These impacts on air quality must be evaluated pursuant to the National Environmental Policy Act (NEPA) and Council on Environmental Quality (CEQ) regulations.

The analysis utilized various sets of existing data. Meteorological data from Cedar Mountain, Sunnyside, Wellington, and U-a/U-b White River were obtained, screened, and summarized. The site specific modeling exercises required the Sunnyside data set. The remaining data sets plus upper air information for Grand Junction and Salt Lake City were used in the regional modeling analysis.

The proposed development is located in complex terrain; thus a detailed description of the topography was required. Maps from the U.S. Geological Survey in various scales were digitized for use in dispersion modeling. Another important parameter in the analysis was demographic data. Detailed population projections for Carbon and Emery counties were supplied by the BLM. These data were then directly used to generate secondary area source emissions for the counties in question.

Air quality significance criteria were determined to achieve compliance with the Clean Air Act and air pollution control laws of the States of Utah and Colorado. Although the proposed development is to occur in Utah, its proximity to the Colorado state line dictated that impacts be also evaluated at Colorado receptors. Due to the pristine characteristics of the area to be developed, it is felt that growth will be controlled mainly by the PSD provisions of the Clean Air Act. Since the present assessment is to satisfy NEPA regulations rather than to support a given PSD permit application, PSD regulations were viewed only with respect to the significance criteria (i.e., PSD increments for TSP and SO_2) in the EIS. PSD Class I areas of concern in the region are Arches, Canyonlands, and Capitol Reef National Parks. Areas of special concern analyzed in some detail were Dinosaur National Monument (Colorado Category I) and the Uintah and Ouray Indian Reservation.

The calculation of emissions was divided into two parts. Area source emissions were obtained from Utah Bureau of Air Quality (UBAQ) county-wide emission estimates. These county totals were gridded into sub-county areas (10 km by 10 km squares) using methods recommended in EPA publications. The emission densities thus obtained were related statistically to UBAQ monitoring data at locations near or within the study region. The calculations show that TSP emissions will double by the year 2005 as a result of population growth alone. If the proposed action is included, TSP emissions will approximately triple by the target year. Other pollutants do not show as dramatic an increase.

Facility emissions were compiled using various information sources. Chief of these were: the plan of operation of Mono Power (a lease-conversion applicant), the Uinta Basin Synfuels EIS, and work done over the past several years by Lawrence Livermore Laboratory and the Laramie Energy Technology Center of DOE. Activity rates (annual tonnage of processed tar sand, disturbed acreage, etc.) for the five proponents were furnished by BLM. It was recognized at the outset that a number of uncertainties existed in the input data.

Fugitive dust due to mining of the tar sand material constitutes by far the most significant source of TSP emissions. Handling and hauling of the material in the very large mining areas under consideration are expected to contribute one half to three quarters of the particulate load. It was found that the mining areas will also be a significant source of NOx emissions due to diesel-powered equipment operating in the mines. Approximately one half of the NOx emissions can be attributed to these sources. The remaining half will come from stacks of extracting and upgrading facilities. These stacks will also be the source of most of the SO_2 emissions which are comparable to emissions from small coal fired power plants. The boilers, furnaces, etc. are assumed to burn either low sulfur coal or coke.

Several air quality simulation models were required to evaluate impacts on both site specific and regional scales. Due to the complexity of the terrain, VALLEY-BID, an EPA screening model, was used for the near-field modeling (less than 40 km). The model estimates for the 24-hour average pollutant concentrations are generally considered conservative for estimating impacts in complex terrain. However, estimates for flat or downsloping terrain may not be the maximum possible impacts. In the long-term mode (annual), it gives annual average concentrations in conjunction with a STAR summary of wind speed and direction by stability class. A STAR deck for Sunnyside was constructed for use with the long-term activation of the model.

Short-term (24 hours) regional impacts of TSP and SO_2 were determined by MESOPUFF, a variable-trajectory Gaussian puff model. MESOPUFF simulates the conversion of sulfur dioxide to sulfates as well as dry and wet deposition; the potential for acid deposition was thus estimated from MESOPUFF results.

Visibility impacts were evaluated by BU426, a model designed to carry out EPA recommended level-2 analysis for assessing plume blight. Visibility impacts to Arches, Canyonlands, and Capitol Reef National Parks, Dinosaur National Monument, and the Uintah and Ouray Indian Reservation were estimated.

Worst-case photochemical smog scenarios were evaluated by the Reactive Plume Model (RPM). Trajectories chosen for the analysis maximized impacts to Arches National Park, the Uintah and Ouray Indian Reservation, and receptors in Colorado.

Violations of the National Ambient Air Quality Standards (NAAQS) for TSP and NO_2 are forecast if either the proposed action or partial conversion alternative is implemented. Additionally, PSD Class II increments for TSP and SO_2 will be exceeded. Although impacts associated with the unitized development alternative are not as severe, the TSP air quality standard and PSD Class II increments for TSP and SO_2 will be exceeded. In general, the SO_2 and NO_2 violation of air quality significance criteria will be localized; impacts will occur principally at nearby elevated terrain. It should be mentioned that stack gas SO_2 and NO_2 impacts may be overpredicted due to the conservative nature of this screening analysis. TSP impacts will be larger in areal extent since they result from surface mining operations.

Estimated concentrations of particulates and SO_2 at Arches, Canyonlands, and Capitol Reef National Parks, and Dinosaur National Monument are below the PSD Class I increments. No perceptible visual impacts from tar sand development are expected at any Class I or Category I areas within the study region. Acidic sulfur deposition resulting from Sunnyside tar sand development was found insignificant -- contributing little to the estimated background deposition flux.

Estimated concentrations of particulates and SO_2 at the Uintah and Ouray Indian Reservation are well below the PSD Class II increments. Impacts on visibility resulting from NOx emissions are expected to occur at the Reservation; plumes will likely be perceptible against the sky or a light background. It should be noted, however, that impacts from the visibility analysis are conservative since all the emissions within the Sunnyside STSA, including those from ground level sources, were combined to form a single plume.

Mitigating measures consisting of a combination of more efficient SO_2 emission controls, higher stacks, and varying plant location will certainly bring the SO_2 impacts below PSD increments. NO_2 impacts are due to both ground-level emissions from equipment at the mines and from elevated releases. It is felt that mitigating measures will certainly reduce the stack gas impacts to well within the NO_2 standard. However, the NO_2 impact due to vehicular traffic at the mines may not be as easily mitigated.

The Sunnyside STSA is likely to remain a non-attainment area for TSP during the majority of the mining years. Implementation of known mitigating measures could significantly decrease TSP emissions but may not completely prevent observed levels from exceeding the standards.

The magnitude and extent of the TSP impacts are not surprising when considering the scope of the projected mining operation. Over 150 million tons of tar sand will be mined each year. For the life of the development, over 4 billion tons of tar sand will be processed. All this activity is expected to take place in a 400 square kilometer area. By comparison, planned surface coal development in the Uinta-Southwestern Utah coal region (Rounds 1 and 2) will approach only 65 million tons and this activity is spread over several counties in Utah.

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1. INTRODUCTION

The Bureau of Land Management (BLM) is preparing a comprehensive site-specific environmental impact statement (EIS) to analyze the potential impacts of converting existing oil and gas leases within the Sunnyside Special Tar Sand Area (STSA) to combined hydrocarbon leases. A map showing the location of the Sunnyside STSA, Carbon County, Utah is shown in Figure 1-1.

The EIS will consist of a site-specific analysis of the collective and cumulative impacts of: (1) the proposed actions consisting of plans of operation for mining and processing tar sand, as required for conversion of five applicant leases in the Sunnyside STSA (each applicant's plan of operation will be analyzed separately and as a collective total of the five proposals) and (2) a partial conversion alternative. A unitized development alternative at two different production levels and a no action scenario are also considered.

Aerocomp, Inc. was instructed to assess the dispersion potential of the area, review the existing air quality, and conduct dispersion modeling to evaluate future impacts upon the air quality of the region. This technical report is to be used as a supporting document to the Sunnyside EIS.

There are many possible methods for mining and processing tar sand, and pollutant emissions vary widely depending on the process used. Although the general extraction method (surface mining or in situ) was indicated by each applicant, other design factors affecting pollutant emission rates were not determined by most applicants. Thus, for most applicants (and for the alternatives), emission inventories were developed. To put emissions in the proper perspective, it should be noted that potential emissions from the smallest tar sand surface mine in this analysis are much greater

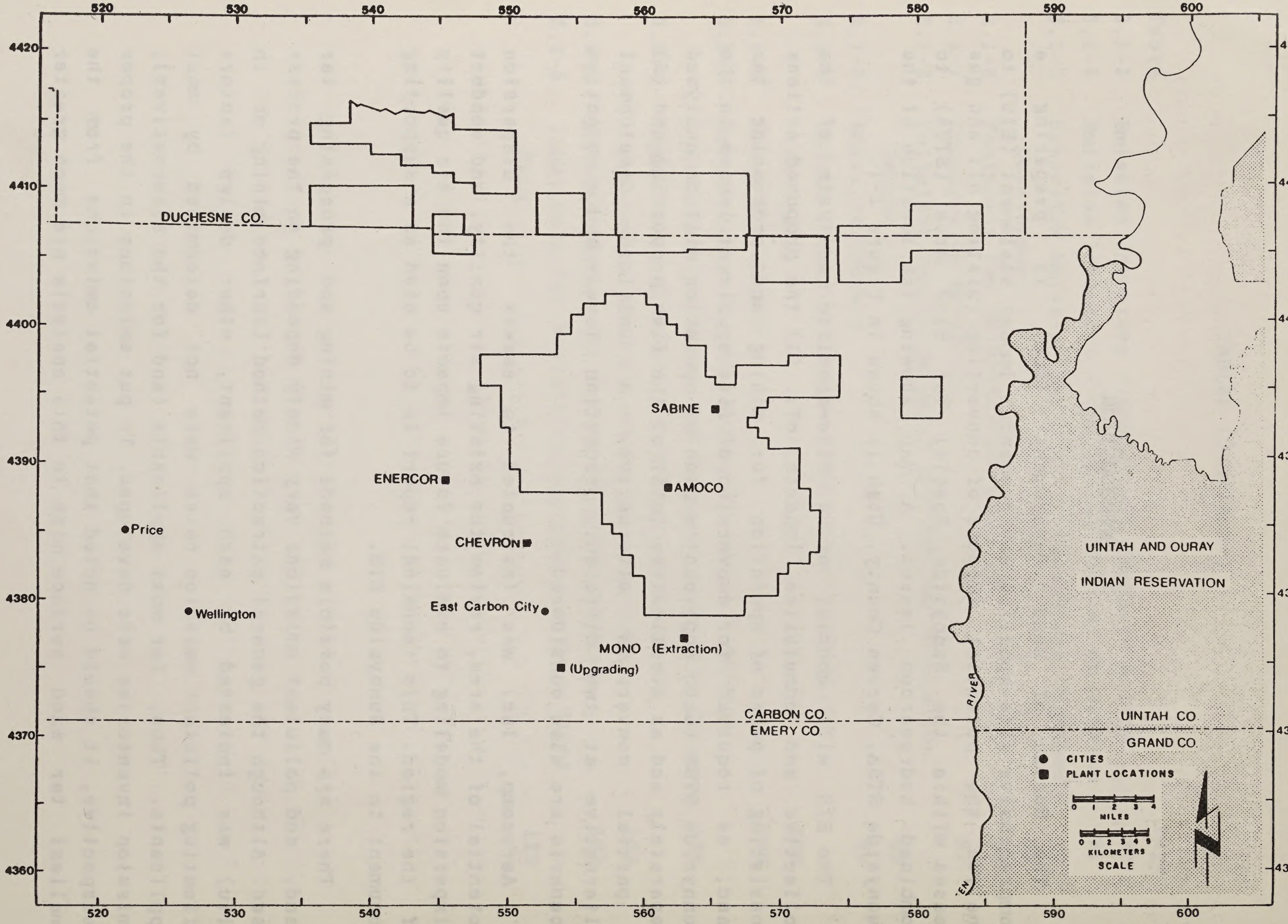

Figure 1-1. Sunnyside STSA and Facility Locations

than the emissions from a very large surface coal mine. Comparatively, a 10 million ton per year surface coal mine is considered very large. Surface mines in this report will remove 14 to 105 million tons of tar sand per year.

This analysis required heavy emphasis on near-source and less emphasis on regional atmospheric dispersion modeling. BLM anticipated that significant issues would include impacts to Federal Class I areas; availability and use of PSD increments; impacts to primitive (potential wilderness) areas, national recreation areas, and Indian reservations; interstate transport of pollutants and use of the affected state's increment; trace elements and hazardous air pollutant emissions; and acid deposition. In these and other issues, close coordination with the National Park Service, EPA Region VIII, BLM, and the Utah Bureau of Air Quality was necessary throughout the study.

It should be emphasized that EIS air quality analysis requirements are much broader than those for PSD permits. While PSD analyses must consider only certain issues addressed in the regulations, the National Environmental Policy Act (NEPA) requires that all potentially significant impacts be addressed. This technical report was not prepared in support of a PSD permit, but to meet the specifications and requirements of NEPA and the current Council on Environmental Quality (CEQ) regulations. These guidelines were followed by Aerocomp in the preparation of the document.

This report contains the environmental consequences of each alternative and a discussion of the methodologies. Mitigating measures and residual impacts are discussed in another document submitted under separate cover.

2. ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND ALTERNATIVES

2.1 PROPOSED ACTION

2.1.1 Affected Environment

2.1.1.1 Topography

The Sunnyside STSA lies within the Book and Roan Cliffs and West Tavaputs Plateau. As noted in Figure 2.1-1, terrain elevations range from 5,000 to 10,000 feet. The study area is bordered to the north by the Uinta Basin and to the west by the West Tavaputs Plateau. The Uintah and Ouray Indian Reservation is located just east and north of the proposed tar sand development. Arches National Park is located approximately 100 km to the southeast and Dinosaur National Monument 120 km to the northeast.

2.1.1.2 Dispersion Climatology

Winds

The meteorological data used in the study region is given in Table 2.1-1. The table contains the station location and the period of record. Annual wind roses for each of the surface stations listed in Table 2.1-1 are illustrated on the map of the study area (see Figure 2.1-2). It should be noted that the data sets are not concurrent.

As noted from Figure 2.1-2, east-southeast winds occur most frequently at U-a/U-b White River with west-southwest winds of secondary importance. This reflects the drainage orientation of the White River, where during weak synoptic situations downslope (east-southeast) flow is expected. The secondary peak out of the west-southwest probably reflects both upslope flow during unstable conditions and prevailing winds at these latitudes.

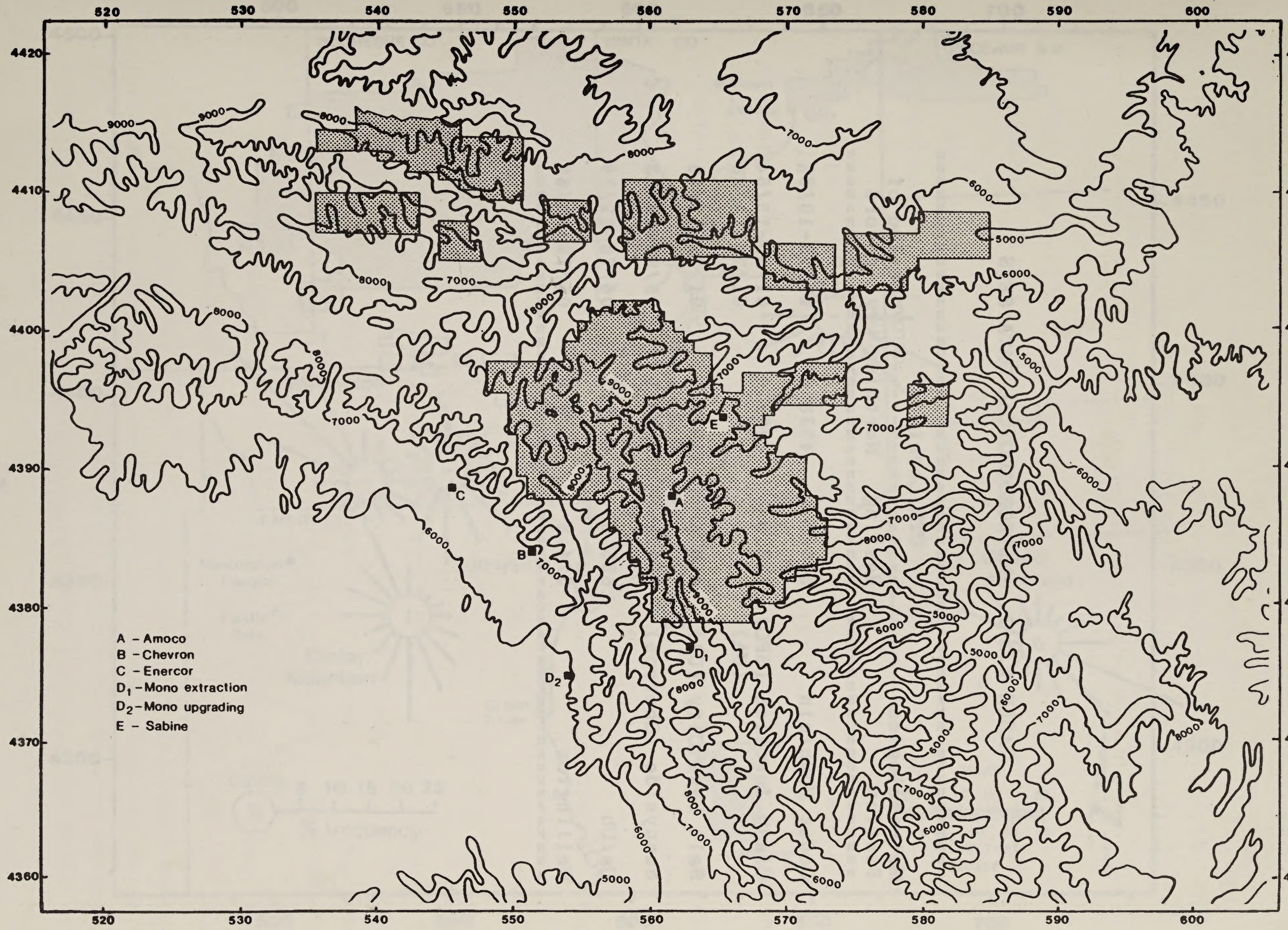

Figure 2.1-1. Topography in the Study Area

TABLE 2.1-1. METEOROLOGICAL DATA SETS

Meteorological Station	UTM Location Easting	UTM Location Northing	Period of record
Cedar Mountain	535.0	4338.0	11/79-10/82
Grand Junction (SFC)	710.0	4329.0	01/55-12/64
(UA)			01/79-12/80
Salt Lake City (UA)	430.0	4515.5	01/79-12/79
Sunnyside (Chevron)	550.5	4380.5	05/82-03/83
Ua/Ub	655.0	4419.5	06/75-12/79
Wellington	524.5	4377.0	05/79-12/80

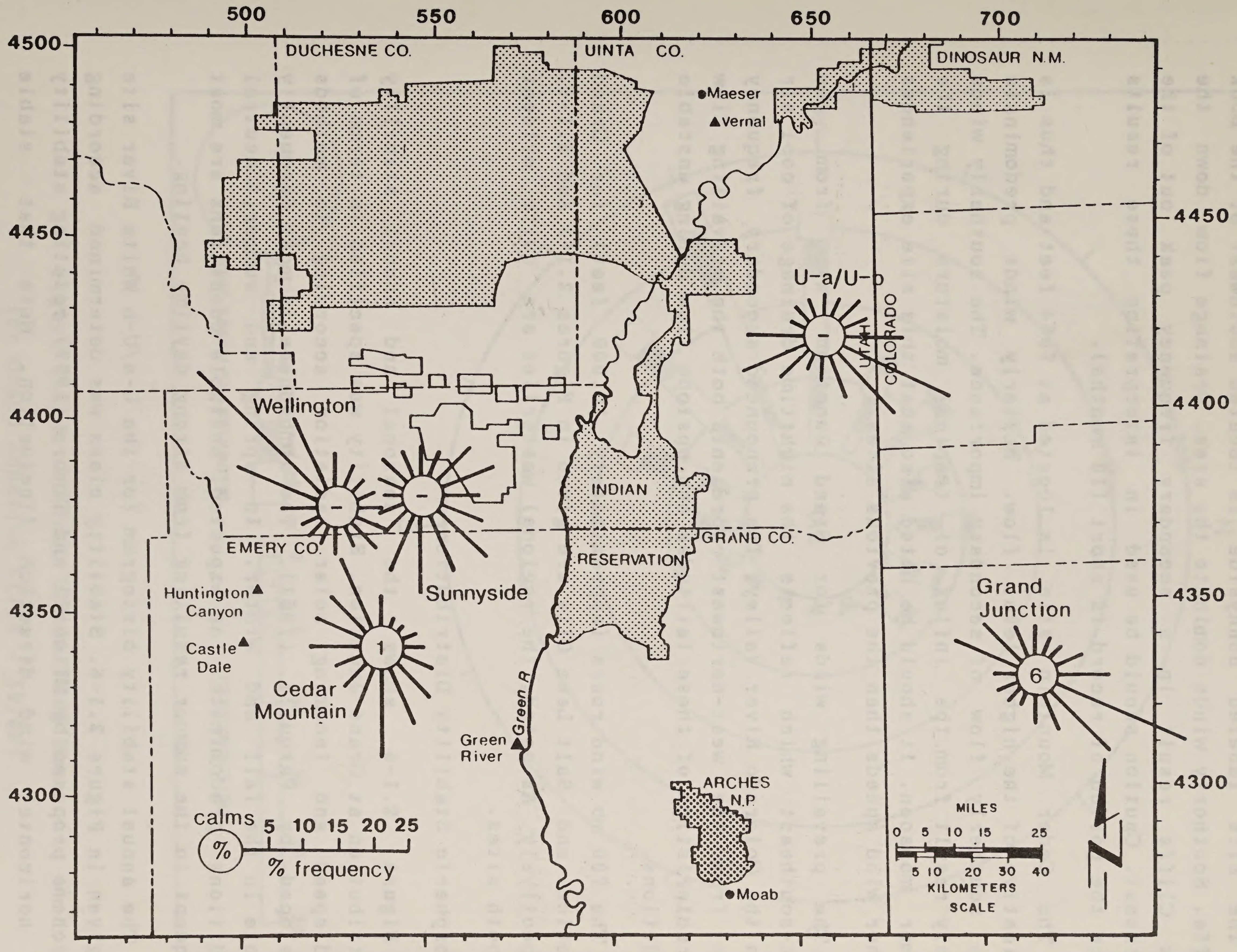

Figure 2.1-2. Annual Wind Roses for Meteorological Stations in the Study Area

The site labeled Sunnyside is located southwest of the Book Cliffs. Southerly winds dominate the area. Drainage flow down the Book Cliffs result in a secondary frequency peak out of the northeast. Caution should be used in interpreting these results since the period of record is short (10 months).

The Cedar Mountain site is located at 7664 feet and thus is indicative of the higher level flow. Westerly winds predominate with southerly flow of secondary importance. The southerly winds likely result from the influx of tropical moisture during the summer monsoon. It should be noted also that this site experiences higher wind speeds than the previous sites.

The prevailing winds for Grand Junction are from the east-southeast which reflects the nighttime drainage of cool air down the Colorado River Valley. The pronounced secondary frequency peak from the west-northwest represents both the prevailing flow characteristics of these latitudes and upslope flow during unstable conditions.

The 700 mb wind roses (approximately 10,000 feet) for Grand Junction and Salt Lake City are given in Figures 2.1-3 and 2.1-4, respectively. As noted, the regional westerlies are quite evident at both sites.

Atmospheric Stability Distribution

Figure 2.1-5 shows the seasonal and annual stability distribution at Grand Junction. Stability was specified in terms of wind speed and incoming solar radiation according to methods developed by Pasquill (1961). The atmosphere is most frequently stable in the fall and winter. In spring and summer, neutral conditions predominate. As expected, unstable conditions are most frequent in the summer resulting from strong daytime heating.

The annual stability histogram for the U-a/U-b White River site is given in Figure 2.1-6. Stability class was determined according a scheme proposed by Mitchell and Timbre (1979) relating stability and horizontal wind direction fluctuation. Note that stable

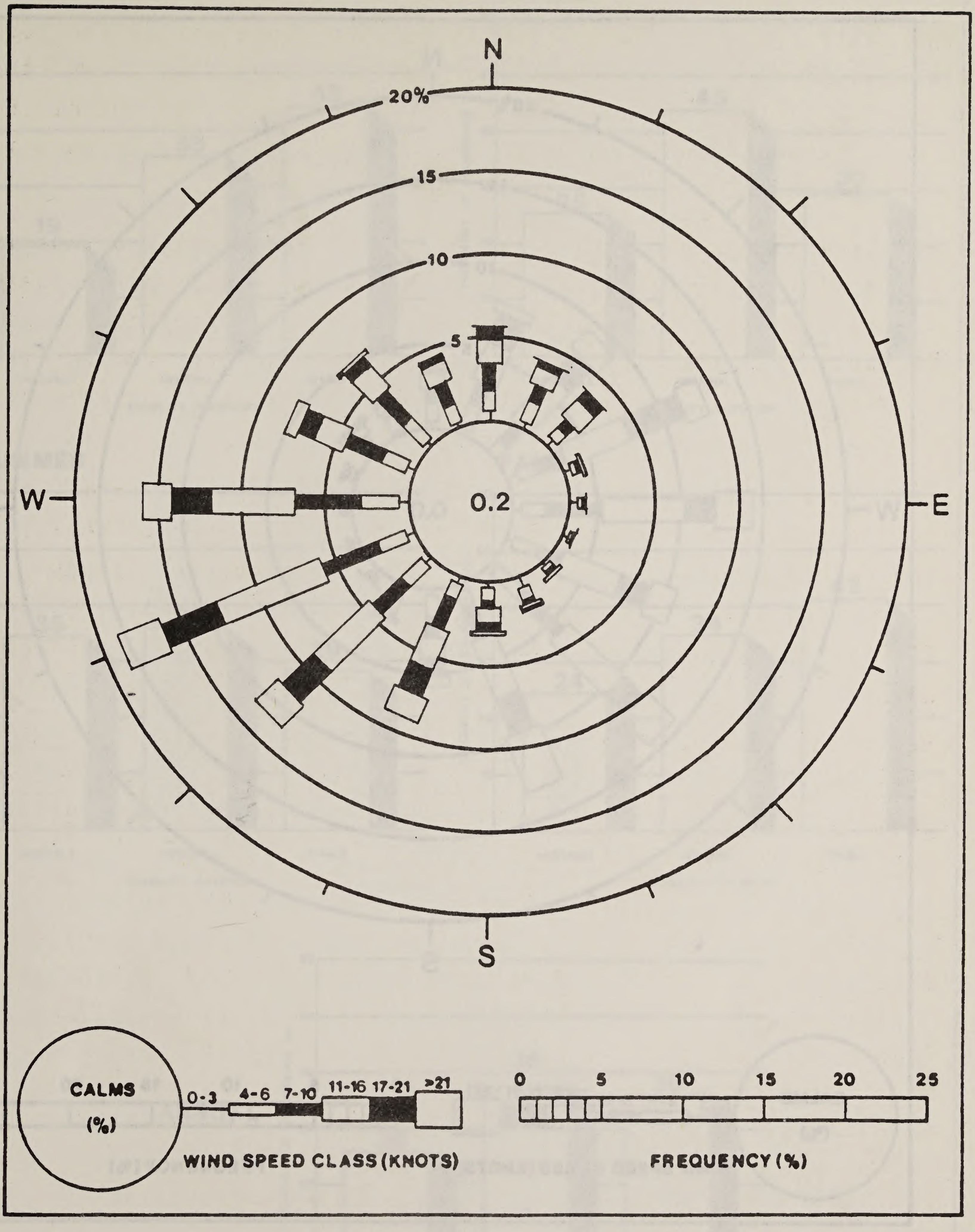

Figure 2.1-3. Annual 700 mb Wind Rose for Grand Junction (1/79 - 12/80)

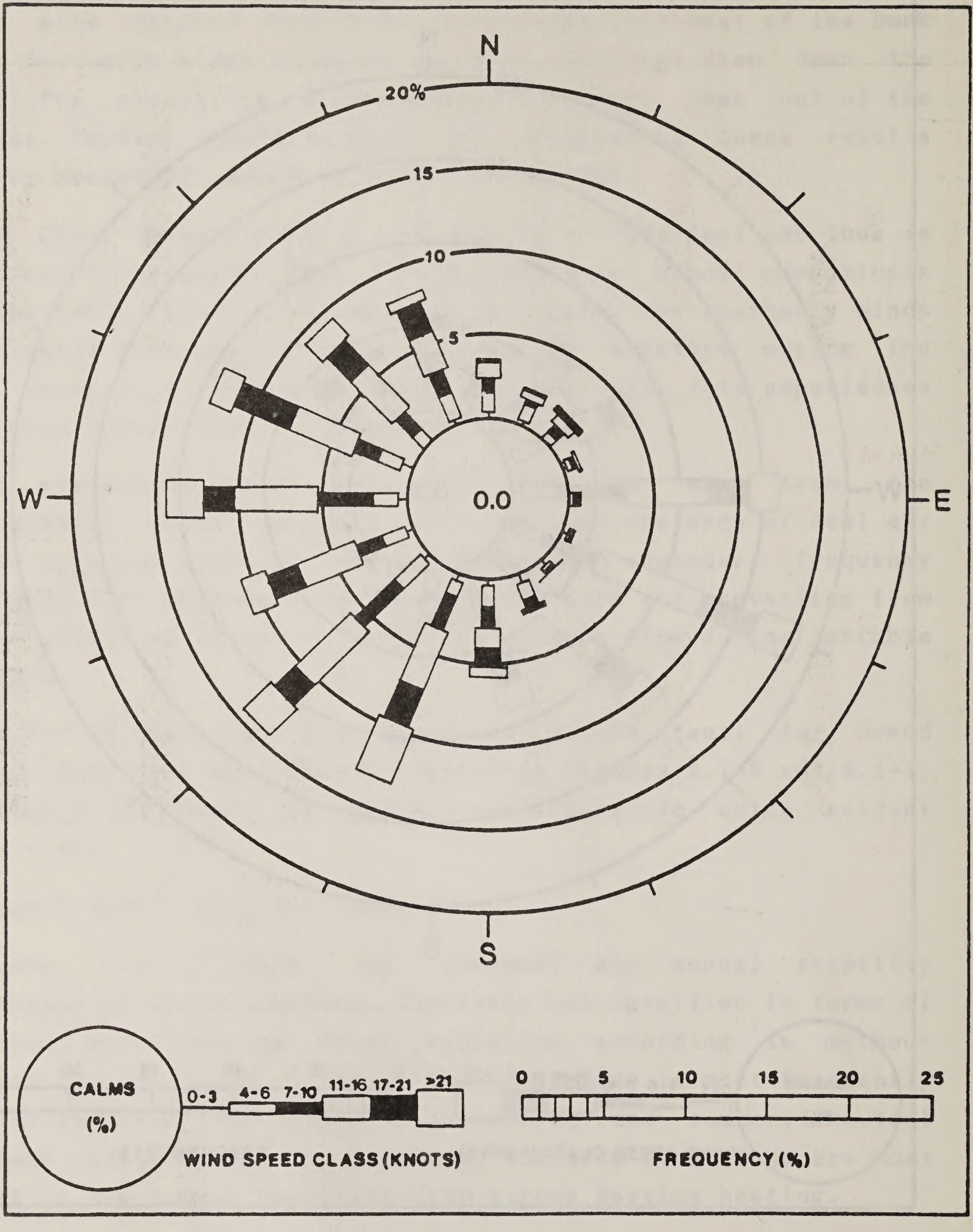

Figure 2.1-4. Annual 700 mb Wind Rose for Salt Lake City (1/79 - 12/79)

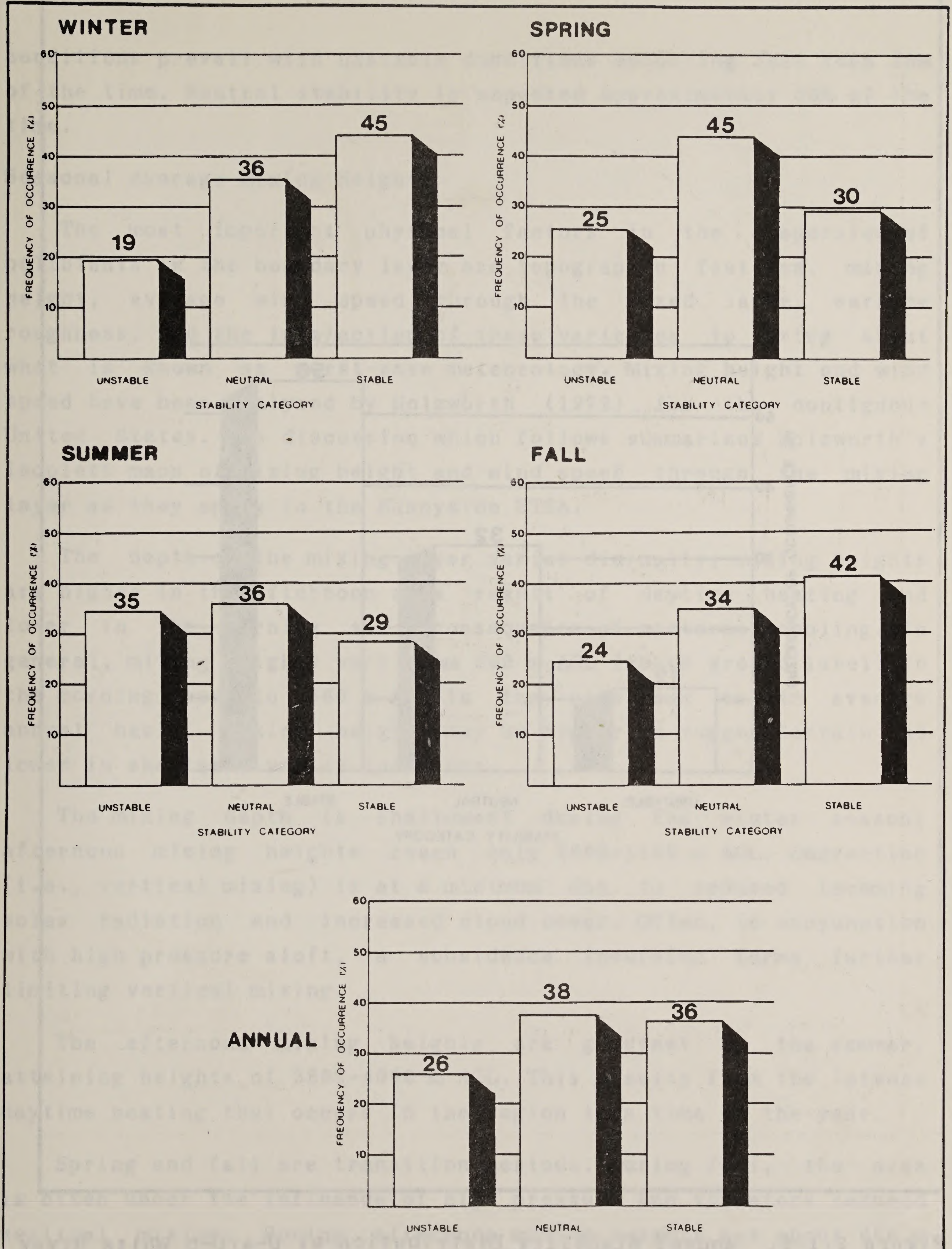

Figure 2.1-5. Seasonal and Annual Distribution of Stability at Grand Junction (1955 - 1964)

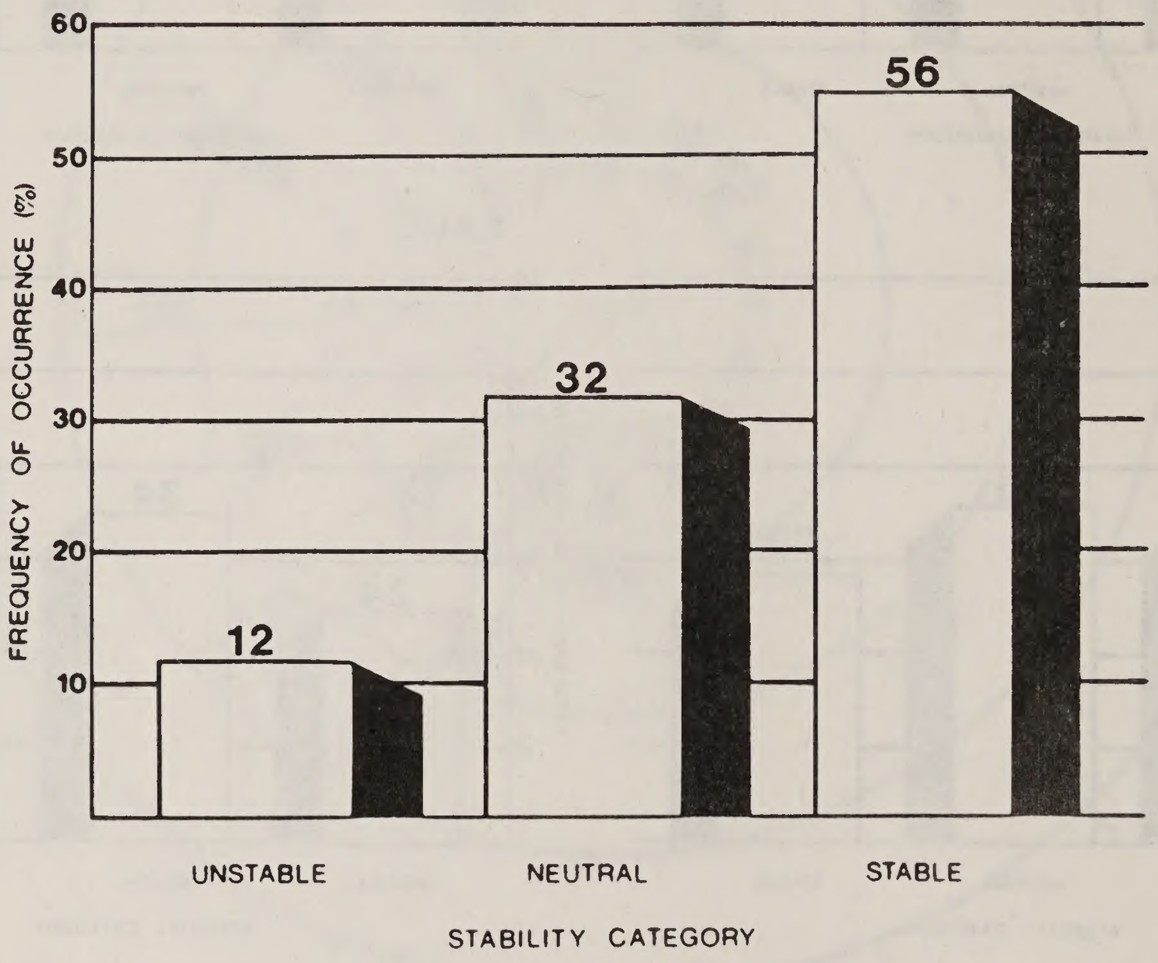

Figure 2.1-6. Annual Stability Distribution at U-a/U-b White River (6/75 - 12/79)

conditions prevail with unstable conditions occurring less than 15% of the time. Neutral stability is expected approximately 30% of the time.

Seasonal Average Mixing Heights

The most important physical factors in the dispersion of pollutants in the boundary layer are topographic features, mixing height, average wind speed through the mixed layer, surface roughness, and the interaction of these variables to bring about what is known as worst-case meteorology. Mixing height and wind speed have been analyzed by Holzworth (1972) for the contiguous United States. The discussion which follows summarizes Holzworth's isopleth maps of mixing height and wind speed through the mixing layer as they apply to the Sunnyside STSA.

The depth of the mixing layer varies diurnally; mixing heights are higher in the afternoon as a result of daytime heating and lower in the morning as a consequence of nocturnal cooling. In general, mixing heights vary from 300 m AGL (above ground level) in the morning hours to 2500 m AGL in the afternoon on an average annual basis. Mixing heights may be higher in rugged terrain and lower in sheltered valley locations.

The mixing depth is shallowest during the winter season; afternoon mixing heights reach only 1000-1100 m AGL. Convection (i.e., vertical mixing) is at a minimum due to reduced incoming solar radiation and increased cloud cover. Often, in conjunction with high pressure aloft, a subsidence inversion forms further limiting vertical mixing.

The afternoon mixing heights are greatest in the summer, attaining heights of 3800-4000 m AGL. This results from the intense daytime heating that occurs in the region this time of the year.

Spring and fall are transition periods. During fall, the area is often under the influence of high pressure and therefore reduced vertical mixing. Spring afternoon mixing heights are about 600 m higher than those observed in the fall due to greater solar insolation.

Wind speeds through the mixed layer also vary diurnally. Morning wind speeds average approximately 4 m/sec; in the afternoon they are about 2 m/sec faster. The seasonal trend in average wind speed through the mixed layer is not nearly as dramatic as that for mixing height. Wind speeds in the boundary layer are generally greater in the spring and summer.

In summary, poor dispersion conditions in the Sunnyside STSA are likely to occur in winter when mixing heights are low and winds are light.

2.1.1.3 Air Quality

Figure 2.1-7 shows the location of air quality monitoring stations within the study region. The region is principally rural with light industrial activity; therefore, the existing air quality for the region is very good. Measured total suspended particulate matter (TSP), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2) concentrations at sites within or near the study region are given in Tables 2.1-2, 2.1-3, and 2.1-4, respectively. With the exception of TSP, ambient concentrations are well within the primary and secondary National Ambient Air Qualtiy Standards (NAAQS). Carbon monoxide (CO) and ozone (O_3) were measured at Sand Wash in 1980 and at White River oil shale project site, U-a/U-b, from 1975 to 1980. For CO, maximum 1-hour concentrations range from 700 to 7400 ug/m^3 and maximum 8-hour concentrations vary from 400 to 4500 ug/m^3. These concentrations are well below the 1-hour and 8-hour standards of 10,000 and 40,000 ug/m^3, respectively. For O_3, maximum 1-hour concentrations range from 135 to 160 ug/m^3 which is below the primary standard of 235 ug/m^3. Lead has not been monitored in the region. Due to the lack of major industrial sources of this pollutant and the relatively low number of vehicles, it is expected that lead concentrations are within the primary NAAQS.

Measured results indicate that the region experiences TSP annual geometric mean concentrations as low as 15-20 ug/m^3 to as

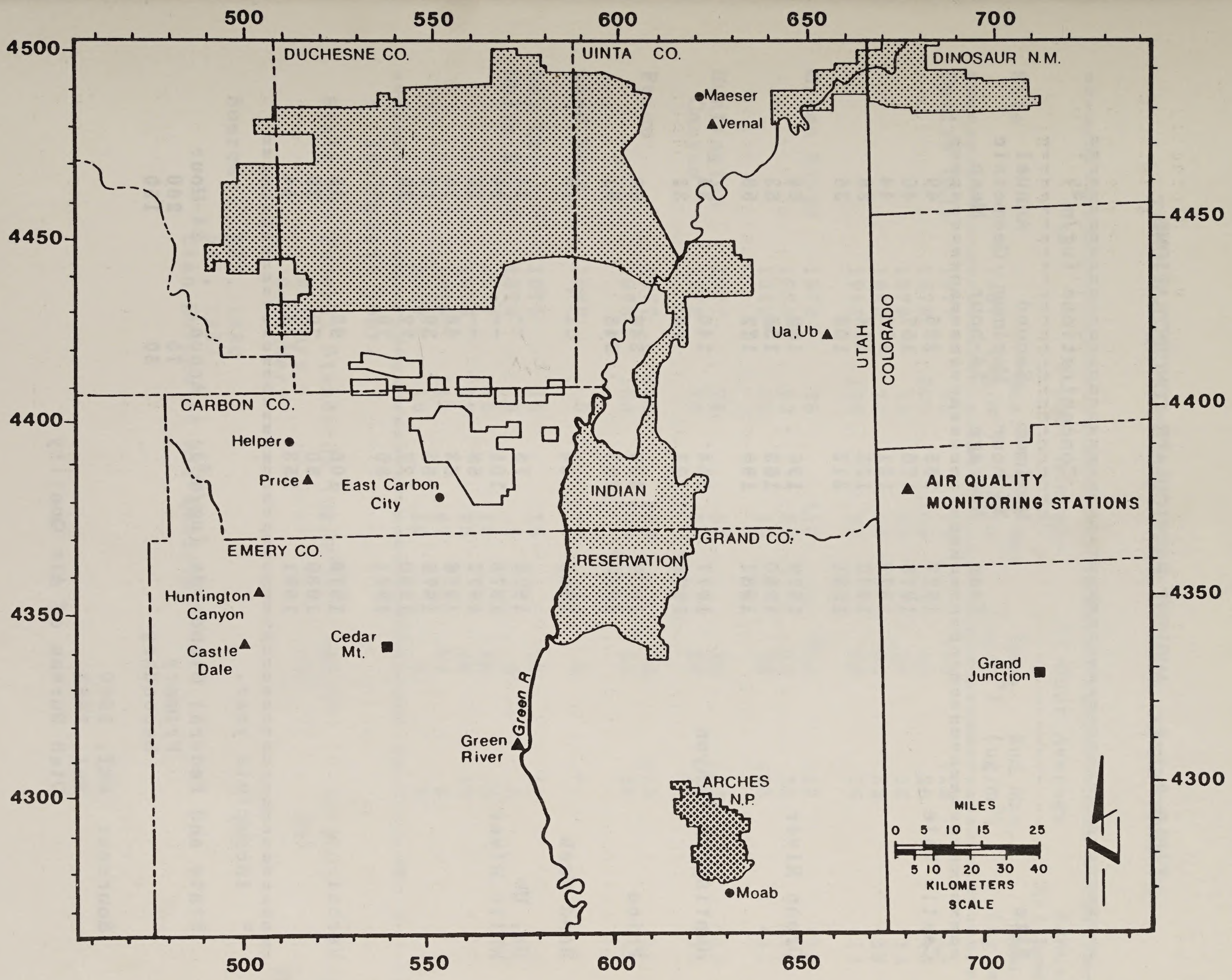

Figure 2.1-7. Air Quality Monitoring Stations in the Study Region

TABLE 2.1-2. AMBIENT PARTICULATE CONCENTRATIONS

Site	Year	Concentrations (ug/m^3) Maximum 24-hour Average	 Second Maximum 24-hour	 Annual Geometric Mean
Castle Dale	1977	265	225	49
	1978	170	157	40
	1979	121	120	44
	1980	125	114	38
	1981	312	108	36
Green River	1979	196	169	64
	1980	163	154	53
	1981	196	172	58
Huntington Canyon	1977	144	140	34
	1978*	93	74	33
Price	1977	406	346	69
	1978*	303	246	61
Sand Wash	1980	84	--	19
Ua, Ub White River	1975	75	--	24
	1976	101	--	24
	1977	58	--	22
	1978	63	48	15
	1979	53	39	13
	1980	127	72	20
	1981	80	79	--
Vernal	1979	106	92	35
	1980	80	79	29
	1981	253	124	44

* Incomplete year.

State and Federal Standards (ug/m^3):	Annual	24-Hour
Primary	75	260
Secondary	60	150

Sources: ERT, 1980
SAI, 1983
Utah Bureau of Air Quality

TABLE 2.1-3. AMBIENT SULFUR DIOXIDE CONCENTRATIONS.

Site	Year	3-Hour Average		24-Hour Average		Annual Arithmetic Mean (ug/m^3)
		Max. (ug/m^3)	2nd Max. (ug/m^3)	Max. (ug/m^3)	2nd. Max. (ug/m^3)	
Castle Dale	1977	26	<13	<13	<13	<13
	1978	208	156	52	26	<13
	1979	78	52	52	26	<13
	1980	78	78	52	52	<13
	1981	130	78	52	26	<13
Green River	1978	26	<13	<13	<13	<13
	1979*	52	52	26	26	<13
	1980*	26	26	26	<13	<13
Huntington Canyon	1977	78	52	26	<13	<13
	1978	78	52	26	<13	<13
Price	1977	130	104	26	<13	10
	1978	156	104	52	26	<13
Sand Wash	1980	5	--	2	--	1
Ua, Ub White River	1975	15	15	10	10	3
	1976	5	5	0	0	0
	1977	15	10	10	5	1
	1978	27	25	14	13	3
	1979	113	47	14	6	0
	1980	16	16	9	8	1

* Incomplete year.

State and Federal Standards (ug/m^3):	Annual	24-Hour	3-Hour
Primary	80	365	--
Secondary	--	--	1300

Sources: ERT, 1980
SAI, 1983
Utah Bureau of Air Quality

TABLE 2.1-4. AMBIENT NITROGEN DIOXIDE CONCENTRATIONS.

Site	Year	Maximum 1-Hour (ug/m^3)	Maximum 24-Hour (ug/m^3)	Annual Arithmetic Mean (ug/m^3)
Castle Dale	1977	80	--	6
	1978	80	--	8
	1979	80	60	[1
	1980*	140	80	20
	1981	100	60	20
Green River	1978	80	--	14
	1979	120	--	20
	1980*	80	--	20
Huntington Canyon	1977	80	--	10
Sand Wash	1980	--	--	6
Ua, Ub	1975	--	--	5
White River	1976	--	--	5
	1977	--	--	0
	1978	--	--	1
	1979	--	--	1
	1980	--	--	2

* Incomplete year.

State and Federal Standards (ug/m^3): Annual
(Primary and Secondary) 100

Sources: ERT, 1980
SAI, 1983
Utah Bureau of Air Quality

high as 60-70 ug/m^3 (see Table 2.1-2). It is probable that populated areas could currently approach the secondary NAAQS for the annual geometric mean. The measurements also show that the annual maximum 24-hour TSP concentrations currently range from 50-400 ug/m^3. These results demonstrate that isolated areas of the study region currently exceed the secondary NAAQS and possibly exceed the primary NAAQS for TSP.

Visibility

Background visual ranges at Dinosaur National Monument, Capitol Reef National Park, and Canyonlands National Park have been measured by the National Park Service, EPA, and John Muir Institute from 1978 to 1981 using multiwavelength telephotometers. The results are summarized in Table 2.1-5. As shown, visibilities in the regions are usually good, with seasonal average visual ranges from 140 km to 229 km. Geometric means of visual range at Dinosaur, Capitol Reef, and Canyonlands are 176 km, 182 km, and 190 km respectively. Moreover, hourly visibility at Cedar Mountain has been measured by the Environmental Protection Agency with a nephelometer from November 1979 to July 1982. A histogram plotting the frequency of occurrence is given in Figure 2.1-8. As shown, the background visual range at Cedar Mountain has a mean value of 207 km, and ranges between about 100 and 350 km. The good visibility conditions reflect the presently low regional sulfur dioxide and ambient TSP concentrations.

TABLE 2.1-5. SEASONAL AVERAGE VISUAL RANGE (km) AT SEVERAL NATIONAL PARKS FROM 1978 TO 1981

Park	Winter	Spring	Summer	Fall
Canyonlands N.P.				
1978	-	-	-	200
1979	200	-	-	191
1980	191	181	-	196
1981	229	162	156	193
4 Year Average	207	172	156	195
Capitol Reef N.P.				
1978	-	-	190	211
1979	180	172	-	181
1980	190	169	163	186
1981	184	190	160	186
4 Year Average	185	177	171	191
Dinosaur N.M.				
1978	-	-	190	-
1979	140	180	179	192
1980	170	170	154	203
1981	212	181	135	-
4 Year Average	174	177	165	198

- Data not available

Other Pollutants

No data exists on ambient concentrations of polyorganic material, ammonia, hydrogen sulfide, radioactive nuclides, and sulfates/nitrates. Given the rural setting of the region and the distance from likely emission sources, it is expected that existing concentrations are insignificant.

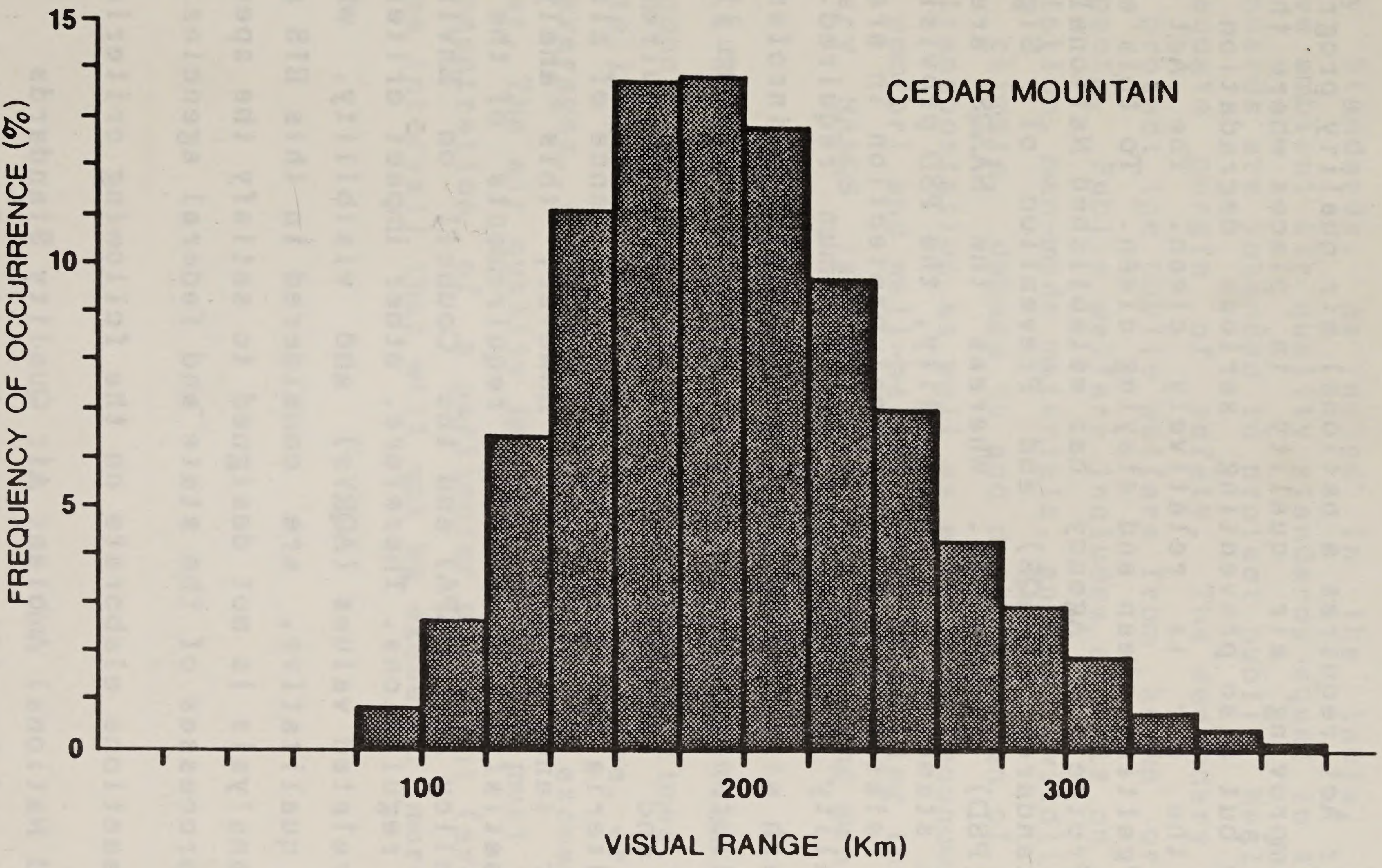

Figure 2.1-8. Visibility Histogram for Cedar Mountain (11/79 - 7/82)

2.1.2 Air Quality Impact Significance Criteria

2.1.2.1 General

The Clean Air Act requires a national air quality program aimed at not only improving air quality in places where the air is relatively dirty but also preventing serious degradation of air quality where the air is relatively clean. The Act has been referred to as "getting clean and staying clean." To this end, the Environmental Protection Agency has established National Ambient Air Quality Standards (NAAQS) and Prevention of Significant Deterioration (PSD) provisions. Whereas the NAAQS are uniform minimum national standards for air quality, the PSD provisions give air quality and related values additional protection in areas where existing air quality is better than the minimum required. States may also establish air quality goals and objectives insofar as they do not allow pollutant levels above the national minimum limits.

The state and federal air quality program requirements are quantitative criteria for assessing the significance of air quality impacts of tar sand development. However, this analysis is conducted to satisfy the broader requirements of the National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) regulations. Therefore, other impact criteria, such as air quality related values (AQRVs) and visibility, which are normally less qualitative, are considered in this EIS analysis. Likewise, this analysis is not designed to satisfy the specific air quality permit processes of the state and federal agencies.

Subsequent sections elaborate on the following criteria:

- State and National Ambient Air Quality Standards
- Prevention of Significant Deterioration Increments
- Air Quality Related Values (including visibility)
- National Emission Standards for Hazardous Air Pollutants
- Other Considerations.

2.1.2.2 State and National Ambient Air Quality Standards (NAAQS)

Table 2.1-6 lists the applicable Utah, Colorado, and Federal Air Quality Standards. As noted in the table, both Utah and Colorado have ambient air quality standards equal to the NAAQS. The primary standards are intended to protect public health, allowing for an adequate margin of safety. The secondary standards are intended to protect the public welfare from known or anticipated adverse impacts. Public welfare includes effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility, climate, damage to and deterioration of property, and hazards to transportation as well as effects on economic values and on personal comfort and well-being. Thus, comparing the impact to the secondary NAAQS is one way of assessing many air quality issues.

Table 2.1-6 shows that standards are written as specific pollutant concentrations for various averaging times (e.g., 1-hour exposure, etc.). Other than the standard for ozone, or those based on annual averages, the standards are not to be exceeded more than once per year. The air quality impact evaluation must address the maximum concentration of a particular pollutant (averaged over a specific time interval) that will not be exceeded more than once per year.

TABLE 2.1-6. UTAH, COLORADO AND NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	Primary	Secondary
Oxidant (ozone)	1 hour*	235 ug/m^3	†
Carbon monoxide	8 hour	10 mg/m^3	†
	1 hour	40 mg/m^3	†
Nitrogen dioxide	Annual	100 ug/m^3	†
Sulfur dioxide	Annual	80 ug/m^3	-
	24 hour	365 ug/m^3	-
	3 hour	-	1300 ug/m^3
Total suspended particulate matter	Annual	75 ug/m^3	60 ug/m^3
	24 hour	260 ug/m^3	150 ug/m^3
Lead	Calendar Quarter	1.5 ug/m^3	†
Hydrocarbons**	3 hour (6-9 AM)	160 ug/m^3	†

Note: National standards, other than for ozone or those based on annual averages, are not to be exceeded more than once per year.

* The number of days during a calendar year in which one or more hourly values could equal or exceed the ozone standard must be less than or equal to 1.

† Same as primary standard.

** Guideline for Oxidant Control, no longer a national standard.

2.1.2.3 Prevention of Significant Deterioration (PSD)

Utah and Colorado areas covered by the PSD provisions of the Clean Air Act are basically divided into two classes. Class I areas are those in which practically any air quality deterioration would be considered significant, thus allowing little or no major energy or industrial activity in close proximity. Class II areas are those in which deterioration which normally accompanies moderate, well-controlled growth would not be considered significant. Different degrees of degradation of air quality are deemed acceptable in the two classes of land. Class I and Class II degradation limits and the secondary NAAQS become the most relevant quantitative criteria to compare the pollutant concentrations resulting from tar sand development.

Colorado has adopted regulations for SO_2 similar in nature to the national PSD provisions. All Federal Class I areas are included in the Colorado Category I classification, although not all Colorado Category I areas are considered in the Federal Class I provisions.

The Act defines specific maximum allowable increases over baseline concentrations for only two pollutants: SO_2 and TSP. Table 2.1-7 lists those allowable increments. The Act also requires the Environmental Protection Agency (EPA) to devise means for preventing significant deterioration of air quality from other pollutants regulated under the Act. This has not yet been accomplished except for a broad interpretation of air quality related values as discussed below.

TABLE 2.1-7. PREVENTION OF SIGNIFICANT DETERIORATION INCREMENTS

Pollutant	Averaging Time	Maximum Allowable Concentrations (ug/m^3) Class 1	Class II
SO_2	Annual	2	20
	24-hour	5	91
	3-hour	25	512
TSP	Annual	5	19
	24-hour	10	37

As part of a PSD review, ambient air quality modeling is required for each pollutant whose emission rate is above certain limits. The pollutants of concern and their corresponding significant, or de minimis, emission levels are presented in Table 2.1-8. These emission rates or the corresponding monitoring exemptions can be used as criteria in NEPA analysis.

TABLE 2.1-8. DE MINIMIS LEVELS

Pollutant	Emission rate	Monitoring Exemptions	
	(tons/year)	(ug/m^3)	Averaging Period
Carbon monoxide	100	575	8-hour
Nitrogen oxides	40	14	Annual
Sulfur dioxide	40	13	24-hour
Particulate matter	25	10	24-hour
Ozone (VOC)	40	N/A	
Lead	0.6	0.1	24-hour
Asbestos	0.007	N/A	
Beryllium	0.0004	0.0005	24-hour
Mercury	0.1	0.25	24-hour
Vinyl chloride	1.0	15	24-hour
Fluorides	3	0.25	24-hour
Sulfuric acid mist	7	N/A	
Hydrogen sulfide (H_2S)	10	0.04	1-hour
Total reduced sulfur (including H_2S)	10	10	1-hour
Reduced sulfur compounds (including H_2S)	10	10	1-hour

The PSD increments are not applicable to Class II areas until a major source or modification submits a completed PSD permit application. Also, the total area encompassed by the Class II area is not subject to the PSD increments, but only that portion considered in the "baseline area." As of this writing, neither a baseline date, baseline concentration, or baseline area has been established within the study region except for small areas in

Emery and Uintah counties. Consequently, the PSD increments are not applicable to most of the study area at this time. This, however, may not be the situation when the combined hydrocarbon developments go through the permit process.

If the PSD increments have been "triggered" at the time of the permit application, the State of Utah will have to ensure that the combined hydrocarbon developments would not cause or contribute to a violation of PSD increments. This could be accomplished by requiring more stringent fugitive emission controls, additional stack gas control technology, alternative siting, or more stringent controls on non-project sources.

The tar sand facilities in this study will be subject to the general air pollution control provisions of the State of Utah. Facilities developed in Utah must file a notice of intent and must receive an order from the Executive Secretary of the Air Conservation Committee permitting the proposed development.

2.1.2.4 Air Quality Related Values

While the PSD increments for SO_2 and TSP are applied uniformly in each of the two classes of land, the Act also contains provisions for determining on a case-by-case basis the extent to which a proposed deterioration in a mandatory Class I area is significant. A proposed degradation (such as impacts from tar sand development) is to be judged by taking into account the air quality related values (AQRVs), including visibility, which are important to the specific Class I area, whether or not the SO_2 or TSP increments are exceeded. AQRV's specifically include visibility but may also include many other identified criteria. Odors, acid deposition, and effects on ecological systems have been identified for some Class I areas.

Currently there are no objective criteria for judging the impact on AQRV other than the secondary NAAQS. In this study, only visibility impairment is discussed in detail since it is the only AQRV considered significant in the planned tar sand development. Acid deposition and other issues are only briefly addressed.

2.1.2.5 National Emission Standards for Hazardous Air Pollutants

As part of the Clean Air Act are the National Emission Standards for Hazardous Air Pollutants (NESHAP). Under the Act, the EPA designates and sets emission standards for hazardous air pollutants (HAP's). To date only seven chemicals have been designated as NESHAP pollutants. These are asbestos, beryllium, mercury, vinyl chloride, benzene, radionuclides, and inorganic arsenic; emission standards have been set for asbestos, beryllium, mercury, and vinyl chloride (40 CFR, Part 61). None of the emission standards presently quantified are specifically applicable to tar sand facilities. However, these standards can be viewed as criteria to be considered in an EIS.

2.1.2.6 Other Considerations

EPA is currently considering the adoption of an air quality standard for inhalable particulates (IP) which are a subset of the current particles included in the TSP standard. The IP particles have smaller diameters than those now considered under TSP. This EPA-proposed action could have considerable implications for all fugitive emission sources including surface mining of tar sands. Since mining emissions typically consist of larger size particulates, fugitive dust impacts would likely be reduced based on the new significance criteria.

If the current TSP standards are revised to exclude the larger particles, then one very significant criteria for judging the impact of mining operations would certainly change. It is not possible at this time to determine how the proposed IP standard would affect mining activities. This may not be ascertained until the magnitude of the standard is set and also the size fraction of the IPs is determined. Similarly, the emission factors used to establish emissions from specific operations would have to be revised to estimate IP-size particles, not TSP-size particles.

2.1.3 Individual Applicant's Impacts

2.1.3.1 General

As discussed in section 2.1.1 the air quality in the vicinity of the Sunnyside STSA is well within most air quality standards and would be considered clean. The only exception to this generally clean condition is TSP. Monitoring of TSP levels has been conducted in Castle Dale, Green River, Huntington Canyon, Price, Sand Wash, U-a/U-b White River, and Vernal for several years. These data indicate that TSP levels in or near most of the larger towns probably exceed both the long-term and short-term standards. Outside these areas the levels are very low and approach natural background.

The current emission inventory provided by the State of Utah clearly demonstrates that dirt roads are the dominant man-made emission source within Price and other cities and towns. If the emission inventories are generally correct, then dirt road emissions are the most significant source of the higher TSP levels. Naturally occurring blowing dust probably causes occasional high TSP levels but not the pervasive long-term high levels monitored in the towns.

Given the estimated population increases (without any tar sand development) and no additional dirt road emission controls, the TSP levels are expected to remain the same or to increase with time. The development of one or more tar sand leases will add to the population and man's activities and will thus further aggravate the current problem in the towns. Mitigation measures can probably correct these existing and future TSP problems in Price and other towns.

Outside cities and towns, the development of the tar sand projects will significantly impact TSP levels. Some surface mines are estimated to potentially emit more particulate matter than the entire city of Price. It is not surprising, then, that TSP levels near those mines are expected to exceed the standards. The

Amoco surface mine and related activities will potentially emit 5 times more than the city of Price and about the same as all sources in Carbon County for 1981. These large emissions within a relatively small area will certainly lead to TSP values well above the standards.

Spatial and temporal distributions of these high TSP levels will depend upon the specific mine, haul road, and access road geometry as the tar sand is removed during the life of the mine. High levels will probably remain within the Sunnyside STSA during the majority of mining years. Implementation of known mitigation measures could significantly decrease the extent of the emissions but may not completely prevent the levels from exceeding the standards.

Sulfur dioxide, nitrogen dioxide, and other pollutant levels are currently low and will remain well within the standards without the development of the tar sand projects. However, the tar sand leases will increase the levels of these and other pollutants.

SO_2 and NO_2 significance criteria will also be exceeded for some alternatives. The PSD Class II increments for SO_2 are estimated to be exceeded due to stack gas plumes impacting elevated terrain. In some cases, the elevated terrain is not in the downwind direction of the expected drainage flow. Thus, on-site meteorological monitoring or tracer tests may show that this analysis has predicted higher impacts than expected. Mitigating measures such as more efficient SO_2 emission controls and/or higher stacks and/or different plant locations will certainly bring the SO_2 impacts within the PSD increments.

NO_2 impacts are due to both ground-level emissions from equipment at the mines and from elevated release from the stacks. The stack gas NO_2 impacts are very localized and may prove to be overpredicted through local wind monitoring or tracer tests. Mitigating measures such as more efficient NO_2 stack gas emission controls and/or higher stacks and/or different plant locations will certainly reduce the stack gas impact to within the NO_2 NAAQS. However, the NO_2 impact due to the mining activities may not be as easily mitigated.

The following sections discuss the various scenarios being considered in the development of the Sunnyside STSA. The scenarios include the proposed action (including individual applicants, collective, and cumulative), partial conversion, unitized development, and the mandatory no action alternative.

The proposed action alternative can be thought of as the high production scenario. Within this scenario is the collective alternative, which includes:

- 50,000 barrel per day (BPD) Amoco mine and facility,
- 20,000 BPD Enercor mine and facility,
- 30,000 BPD Mono mine and facility, and
- 5,000 BPD Sabine in situ facility.

The cumulative alternative includes all the above development plus a 10,000 BPD Chevron private mine and facility.

Partial conversion is a lesser development scenario. Within this action the collective alternative includes:

- 75,000 BPD mine and facility, and
- 5,000 BPD in situ facility.

Again, cumulative action includes the above development plus a 10,000 BPD Chevron private mine and facility.

The unitized development scenario assumes slightly less development than the partial conversion alternatives and that development will be centralized. The collective alternative consists of a 50,000 BPD mine and facility and the cumulative alternative assumes a 50,000 BPD mine and facility plus a 10,000 BPD Chevron private mine and facility.

Also analyzed was a no action alternative which included emissions from assumed population growth and emissions associated with Chevron's 10,000 BPD private mine and facility.

Table 2.1-9 lists the TSP and SO_2 impacts for each alternative compared with the PSD increments. This table will be referenced in the following sections.

2.1.3.2 Amoco

Table 2.1-10 lists the projected maximum impact of the Amoco project as related to the National Ambient Air Quality Standards. The table is only applicable to the area where the maximum estimated level of a specific pollutant is expected to occur. Relative contributions of a particular source will vary according to the distance from that source. For instance, the 2005 Baseline sources will contribute 24 ug/m^3 to the annual average TSP value at the maximum receptor and Amoco will contribute 170 ug/m^3. However, near the towns Amoco will contribute only slightly to the estimated levels. TSP and NO_2 are expected to exceed the NAAQS due to the Amoco project. Increases in TSP and SO_2 ambient levels above baseline will exceed the PSD Class II increments.

The TSP impact is approximately 10 times higher than the PSD increments. Such a large impact probably cannot be mitigated. However, the 24-hour SO_2 impact is only about 50% higher than the PSD increment and occurs due to the complexity of the terrain. More efficient emission controls, higher stacks, and/or different plant locations certainly can mitigate the SO_2 impacts.

The high NO_2 ambient concentration is caused by the stack gas plume impacting a relatively small elevated terrain area. NOx control, higher stacks, and/or different plant locations will fully mitigate this effect.

TABLE 2.1-9. SUMMARY OF PSD INCREMENT CONSUMPTION FOR EACH ALTERNATIVE.

Areas of Special Concern Alternatives	Average Concentrations SO_2 (ug/m^3) 3-hour	 24-hour	 Annual	 TSP (ug/m^3) 24-hour	 Annual
Class II Areas					
PSD class II increment	512	91	20	37	19
Receptors with maximum impact					
Amoco	474	130	14	685	172
Enercor	252	70	1	163	41
Mono	576	160	8	175	44
Sabine	612	170	7	44	12
Chevron - private mine only	--	--	--	154	39
Proposed Action: Collective	612	170	15	723	181
Proposed Action: Cumulative	612	170	18	723	181
Partial Conversion: Collective	1044	290	22	431	108
Partial Conversion: Cumulative	1044	290	22	431	108
Unitized Development: Collective	312	120	12	596	149
Unitized Development: Cumulative	374	144	12	711	178
No Action Alternative	126	35	3	154	39
Uinta & Ouray Indian Reservation					
Amoco	8	2	<1	<1	<1
Enercor	3	1	<1	<1	<1
Mono	3	1	<1	<1	<1
Sabine	5	2	<1	<1	<1
Chevron - private mine only	--	--	--	<1	<1
Proposed Action: Collective	12	3	<1	<1	<1
Proposed Action: Cumulative	14	4	<1	<1	<1
Partial Conversion: Collective	9	3	<1	<1	<1
Partial Conversion: Cumulative	11	3	<1	<1	<1
Unitized Development: Collective	8	2	<1	<1	<1
Unitized Development: Cumulative	9	3	<1	<1	<1
No Action Alternative	2	1	<1	<1	<1

-- Not modeled.

Note: Selection of a different grid origin could result in slightly different maximum concentrations and locations of those maximum due to the terrain variability.

TABLE 2.1-10. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - AMOCO

Pollutant	Source Category Contributions (ug/m^3)					
Ave. Time	2005 Baseline Sources	Inter-related Sources	Project Sources		Maximum Concentration	NAAQS
			Secondary	Direct		
SO_2						
3-hour	18	NA	0	474	492	1300
24-hour	7	NA	0	130	137	365
Annual	1	NA	0	14	15	80
TSP						
24-hour	84	NA	6	679	769	150
Annual	24	NA	2	170	196	60
NO_2						
Annual	2	NA	0	119	121	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

2.1.3.3 Enercor

Table 2.1-11 compares the maximum impact of the Enercor project with the NAAQS. As listed, Enercor sources will cause violations of the TSP significance criteria but all other pollutants are expected to remain well below the criteria. Mitigating measures for fugitive dust control may reduce the TSP impact to within the NAAQS and PSD increments.

TABLE 2.1-11. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - ENERCOR

Pollutant	Source Category Contributions (ug/m^3)					
Ave. Time	2005 Baseline Sources	Inter-related Sources	Project Sources Secondary	Project Sources Direct	Maximum Concentration	NAAQS
SO_2						
3-hour	18	NA	0	252	270	1300
24-hour	7	NA	0	70	77	365
Annual	1	NA	0	1	2	80
TSP						
24-hour	62	NA	0	163	225	150
Annual	19	NA	0	41	60	60
NO_2						
Annual	2	NA	0	16	18	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

2.1.3.4 Mono Power

Information provided by Mono Power on the proposed project was the most comprehensive and thus facilitated greatly this analysis. Mono Power's proposed control techniques included several measures to mitigate ducted emissions as well as fugitive dust sources. The modeling analysis indicates that TSP NAAQS may be violated but all other pollutants will be well below the NAAQS. Table 2.1-12 lists Mono Power's impact as compared with the NAAQS. Further refinements in dispersion modeling during the permit phase may indicate no violations of the annual standard for TSP.

The PSD Class II increment for TSP is likely to be exceeded by a larger margin, indicating that it may be difficult to fully mitigate the TSP impacts. However, the estimated exceedance of the SO_2 PSD increments should be mitigated easily. The small area of maximum SO_2 impact is in elevated terrain. Refined modeling, on-site meteorological data, or tracer tests may show that the impact is much less than predicted herein.

TABLE 2.1-12. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - MONO POWER

Pollutant	Source Category Contributions (ug/m^3)					
Ave. Time	2005 Baseline Sources	Inter-related Sources	Project Sources		Maximum Concentration	NAAQS
			Secondary	Direct		
SO_2						
3-hour	18	NA	0	576	594	1300
24-hour	7	NA	0	160	167	365
Annual	1	NA	0	8	9	80
TSP						
24-hour	84	NA	6	175	265	150
Annual	24	NA	2	44	70	60
NO_2						
Annual	2	NA	0	67	69	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

2.1.3.5 Sabine

No surface mine will be asociated with the Sabine development and thus the potential TSP problems are minor. Table 2.1-13 shows no expected violations of the NAAQS for any pollutant. PSD increments for SO_2 and TSP may be violated, however. In this as in other borderline cases, refined modeling during the permit phase may show that the projected levels will not exceed the increments. SO_2 PSD Class II increments are expected to be violated in a small area of elevated terrain southwest of the site. The estimated SO_2 emission rates are based upon sparse information. More detailed information, which would be required for the PSD permit phase, may show lower emission rates. Application of control measures such as SO_2 scrubbers or alternative fuels would definitely mitigate the adverse impact. More refined modeling or on-site data may show the SO_2 impact to be lower than predicted.

TABLE 2.1-13. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - SABINE

Pollutant	Source Category Contributions (ug/m^3)					
Ave. Time	2005 Baseline Sources	Interrelated Sources	Project Sources		Maximum Concentration	NAAQS
			Secondary	Direct		
SO_2						
3-hour	18	NA	0	612	630	1300
24-hour	7	NA	0	170	177	365
Annual	1	NA	0	7	8	80
TSP						
24-hour	84	NA	6	38	128	150
Annual	24	NA	.2	10	36	60
NO_2						
Annual	2	NA	0	6	8	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

2.1.3.6 Chevron

A surface mine proposed by Chevron capable of producing 10,000 BPD of bitumen was considered as part of the proposed action. The incremental TSP impacts of the surface mine are 39 ug/m^3 for an annual average and 154 ug/m^3 for the 24-hour maximum. These values are added to the impacts for the baseline sources to yield a maximum predicted total impact of 79 ug/m^3 for the annual and 302 ug/m^3 for the 24-hour maximum. Both the Class II increments and the NAAQS are expected to be violated due to the Chevron surface mine.

2.1.4 Collective Impacts

Table 2.1-14 lists the impacts compared to the NAAQS and Figure 2.1-9 shows the estimated annual average TSP levels due to the proposed action collective impacts. The figure does not include the estimated background concentrations of 20 ug/m^3. Therefore, the isopleth representing 40 ug/m^3 indicates the area expected to exceed the TSP NAAQS (60 ug/m^3). An area encompassing both Price and Wellington is expected to exceed the annual standard as well as an area within the Sunnyside STSA.

SO_2 is expected to be well below the NAAQS but the PSD Class II increments may be violated due to elevated emissions in complex terrain. The areas that are estimated to be above the SO_2 Class II increments are generally within 2 km of the plants. In each case, the winds would have to carry the plume toward the higher elevations under very stable atmospheric conditions. No on-site data are available to confirm this assumption. General drainage flow would tend to carry the plumes away from the impacted terrain. Refined modeling or on-site data may show that the predicted SO_2 levels are higher than in actuality. If the reported SO_2 impacts are correct, the actual impacts could be easily mitigated by more efficient controls and/or higher stacks and/or different plant locations.

The expected annual average NO_2 concentrations are shown in Figure 2.1-10. Two receptor grid points show that the NAAQS for NO_2 may be exceeded. One receptor is mainly impacted by the Amoco plant stack gases while the other is affected by the Amoco mining activities. On-site data or refined modeling may show that the predicted levels are higher than what may actually occur. The NOx impacts of this magnitude can be easily mitigated with appropriate controls, and/or taller stacks, and/or moving the plant to a different location.

TABLE 2.1-14. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - PROPOSED ACTION COLLECTIVE

Pollutant Ave. Time	Source Category Contributions (ug/m^3) 2005 Baseline Sources	Inter-related Sources	Project Sources Secondary	Project Sources Direct	Maximum Concentration	NAAQS
SO_2						
3-hour	18	NA	0	612	630	1300
24-hour	7	NA	0	170	177	365
Annual	1	NA	0	15	16	80
TSP						
24-hour	84	NA	6	717	807	150
Annual	24	NA	2	179	205	60
NO_2						
Annual	2	NA	0	128	130	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

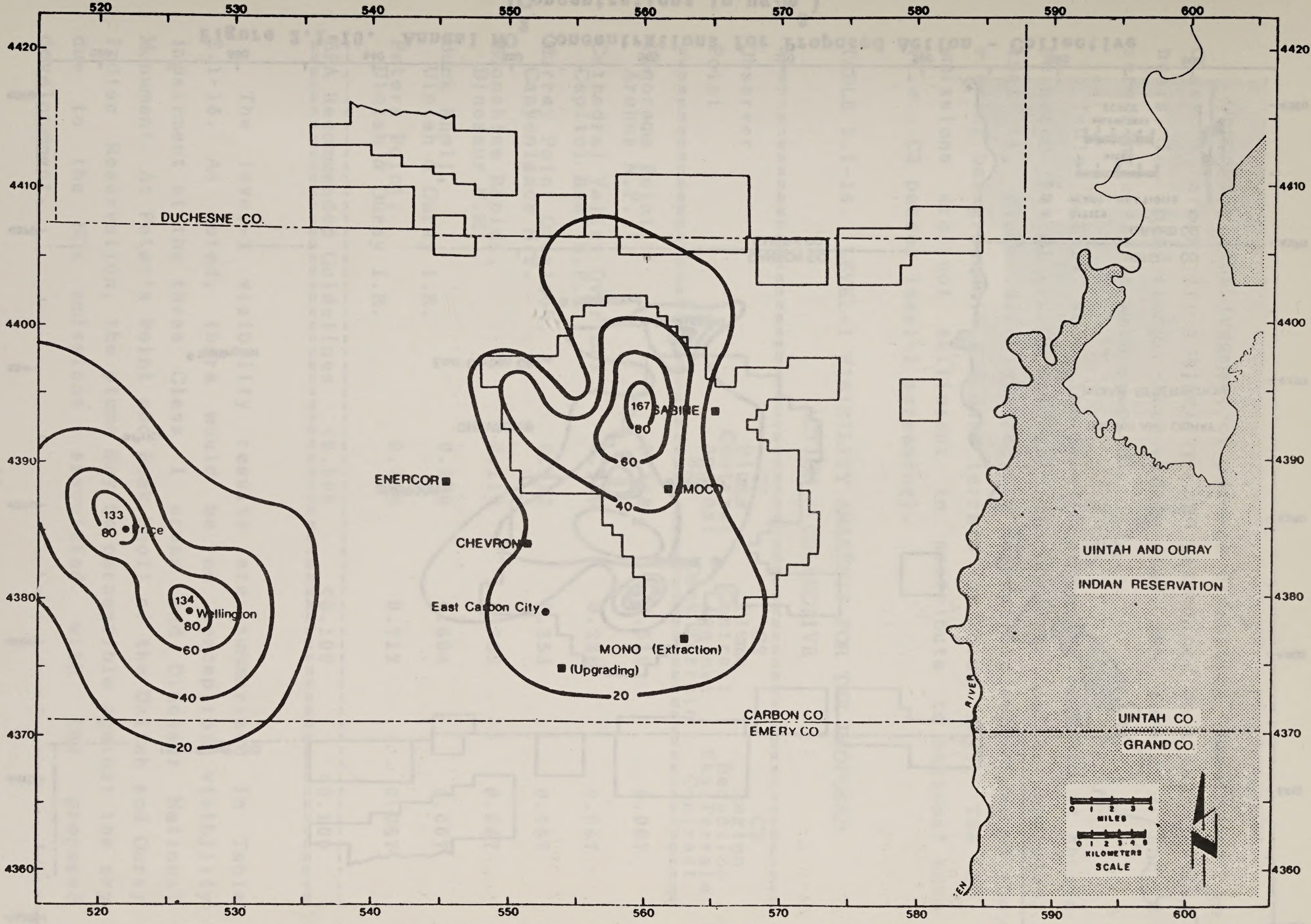

Figure 2.1-9. Annual TSP Concentrations for Proposed Action - Collective
(Concentrations in ug/m^3)

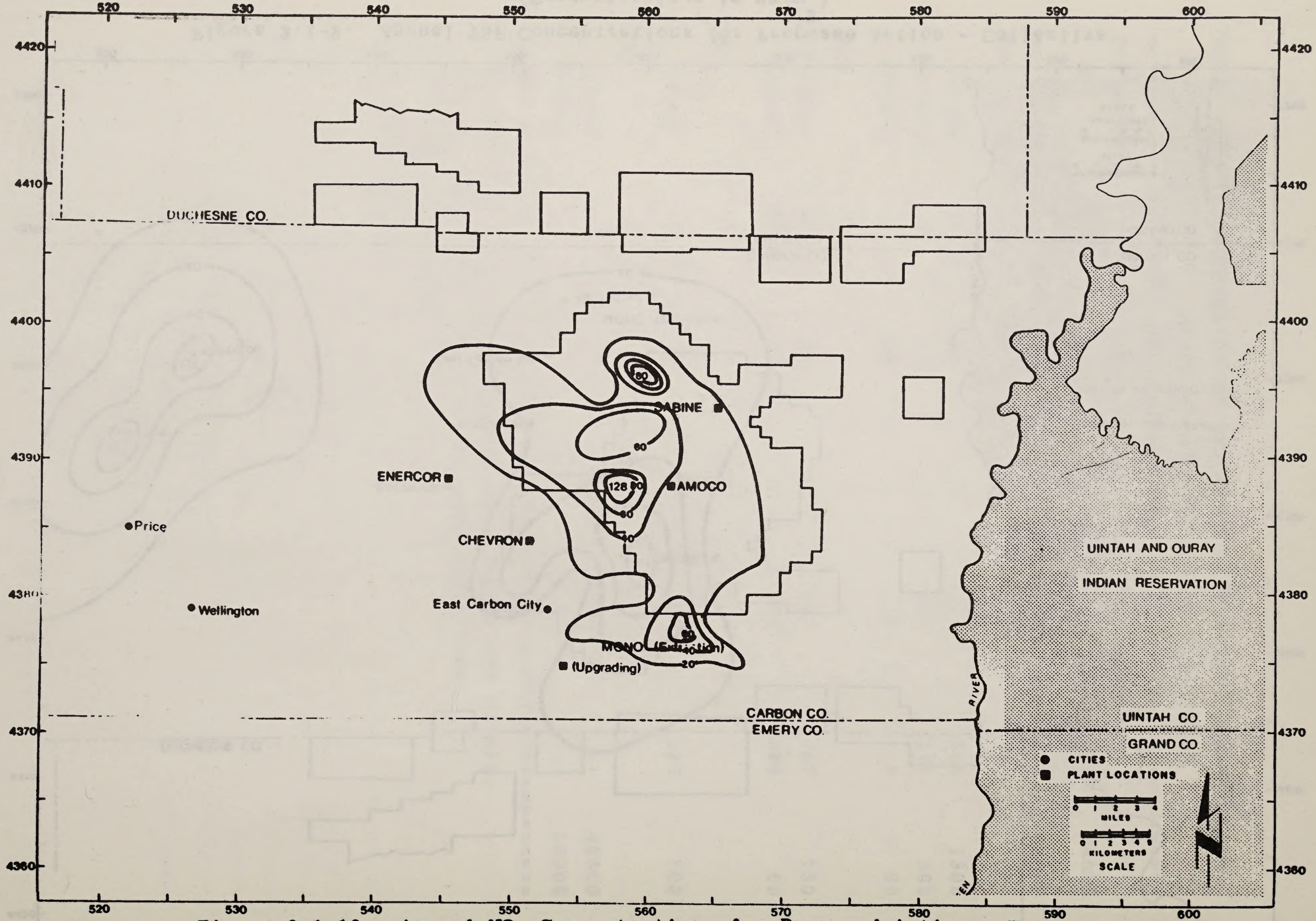

Figure 2.1-10. Annual NO_2 Concentrations for Proposed Action - Collective (Concentrations in ug/m^3)

Currently, the judgment of adverse visibility impairment in Class I areas is subjective and determined on a case-by-case basis. In this study, the widely-used EPA levels 1 and 2 screening criteria were adopted.

Table 2.1-15 shows the level-1 screening results. It should be noted that C1 and C2 fail for all observer points analyzed, that is, plume discoloration is perceptible regardless of the viewing background (i.e., dark terrain or blue sky). The SO_2 emissions are not sufficient to contribute to regional haze (i.e., C3 passes level-1 screening).

TABLE 2.1-15. LEVEL-1 VISIBILITY ANALYSIS FOR THE PROPOSED ACTION - COLLECTIVE

Observer Point	C1 Plume Contrast Against Sky	C2 Plume Contrast Against Dark Terrain	C3 Region Reduction Sky/Terrain Contrast
Panorama Point, Arches N.P.	0.128	0.319	0.067
Cathedral Valley Overlook, Capitol Reef N.P.	0.106	0.228	0.067
Murray Point Overlook, Canyonlands N.P.	0.112	0.253	0.067
Moonshine Rapids, Dinosaur N.M.	0.119	0.280	0.067
Buck Knoll, Uintah & Ouray I.R.	0.179	0.604	0.067
Peters Point, Uintah & Ouray I.R.	0.194	0.712	0.067
EPA Recommended Guidelines	<0.100	<0.100	<0.100

The level-2 visibility results are summarized in Table 2.1-16. As noted, there would be no perceptible visibility impairment at the three Class I areas and Dinosaur National Monument. At Peter's Point and Buck Knoll of the Unitah and Ouray Indian Reservation, the plume may be perceptible against the sky due to the NOx emissions associated with the proposed developement.

TABLE 2.1-16. LEVEL-2 VISIBILITY ANALYSIS FOR THE PROPOSED ACTION - COLLECTIVE

Observer Point	Contrast Reduction*	Visual Range Reduction (%)*	Blue-Red Ratio†
Panorama Point, Arches N.P.	0.040	3.8	0.94
Cathedral Valley Overlook, Capitol Reef N.P.	0.035	3.4	0.98
Murray Point Overlook, Canyonlands N.P.	0.038	3.6	0.98
Moonshine Rapids, Dinosaur N.M.	0.029	2.7	0.93
Buck Knoll, Uintah & Ouray I.R.	0.089	9.6	0.71
Peters Point, Uintah & Ouray I.R.	0.037	3.5	0.70
EPA Recommended Guidelines	<0.100	<11.0**	>0.90

* Wavelength = 0.55 um

** Visual range reduction criteria of 11% is calculated based on the EPA recommended contrast reduction criteria of 0.1 and an observer-terrain distance of 50 km.

† Blue/Red Ratio = [1+Contrast(0.4 um)]/[1+Contrast(0.7 um)]

2.1.5 Cumulative Impacts

Table 2.1-17 lists the proposed action cumulative impacts compared to the NAAQS at the receptors showing the highest concentration. The maximum receptor impacts are very similar to the ones reported for the collective alternatives due to the dominance of a few sources. Figure 2.1-11 and 2.1-12 show the expected annual average concentrations of TSP and NO_2, respectively. Slight increases in the overall concentrations above the collective alternative can be observed. However, the maximum receptor concentrations are essentially equal except for NO_2.

This is the only alternative specifically modeled for CO. The CO impact potential is very low, even for this "high production" alternative.

TABLE 2.1-17. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - PROPOSED ACTION CUMULATIVE

Pollutant Ave. Time	Source Category Contributions (ug/m^3) 2005 Baseline Sources	Inter-related Sources	Project Sources Secondary	Direct	Maximum Concentration	NAAQS
SO_2						
3-hour	18	0	0	612	630	1300
24-hour	7	0	0	170	177	365
Annual	1	3	0	15	19	80
TSP						
24-hour	84	0	6	717	807	150
Annual	24	0	2	179	205	60
NO_2						
Annual	2	49	0	128	179	100
CO						
1-hour	1500	0	0	236	1736	40000
8-hour	900	0	0	165	1065	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

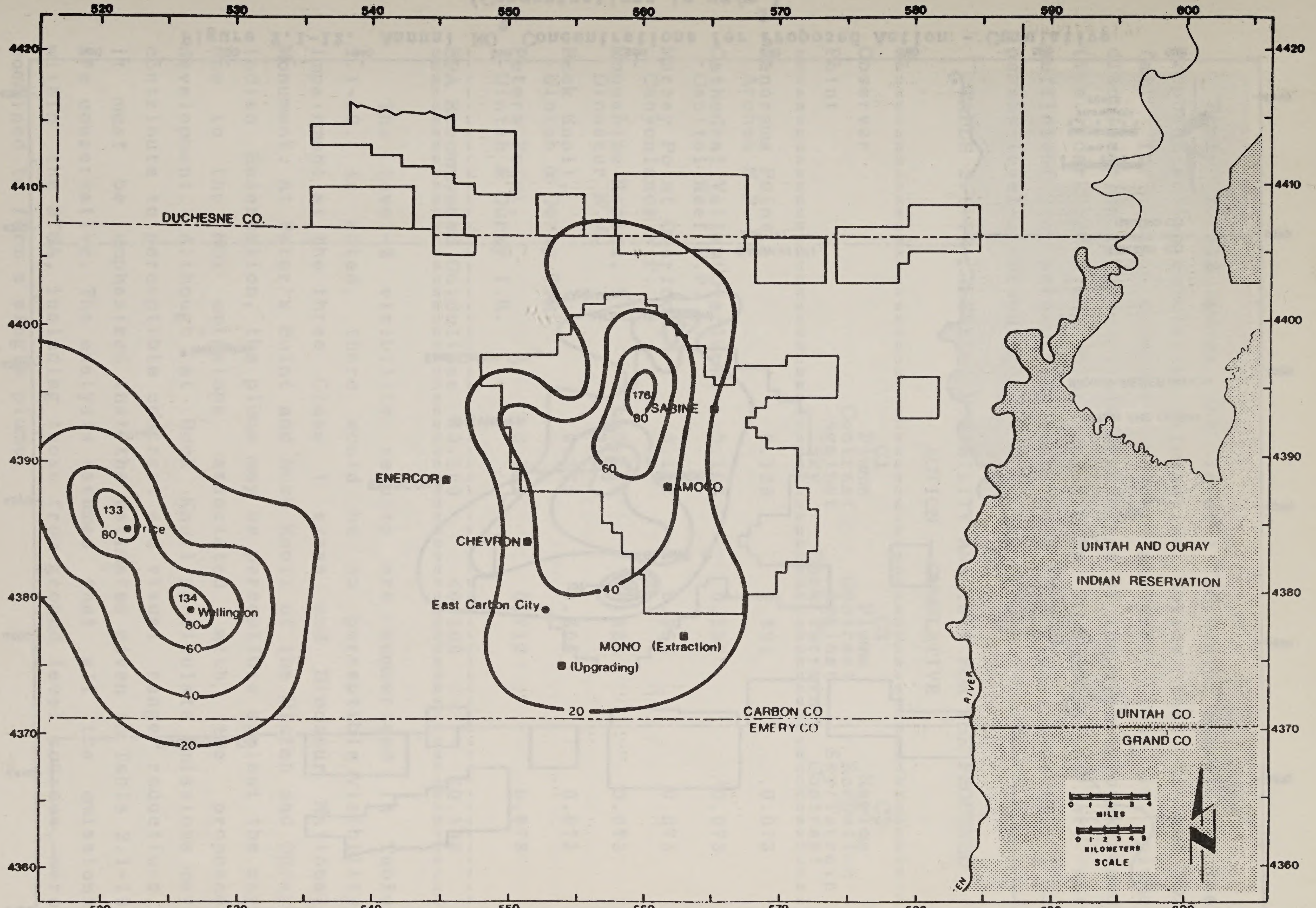

Figure 2.1-11. Annual TSP Concentrations for Proposed Action - Cumulative (Concentrations in ug/m^3)

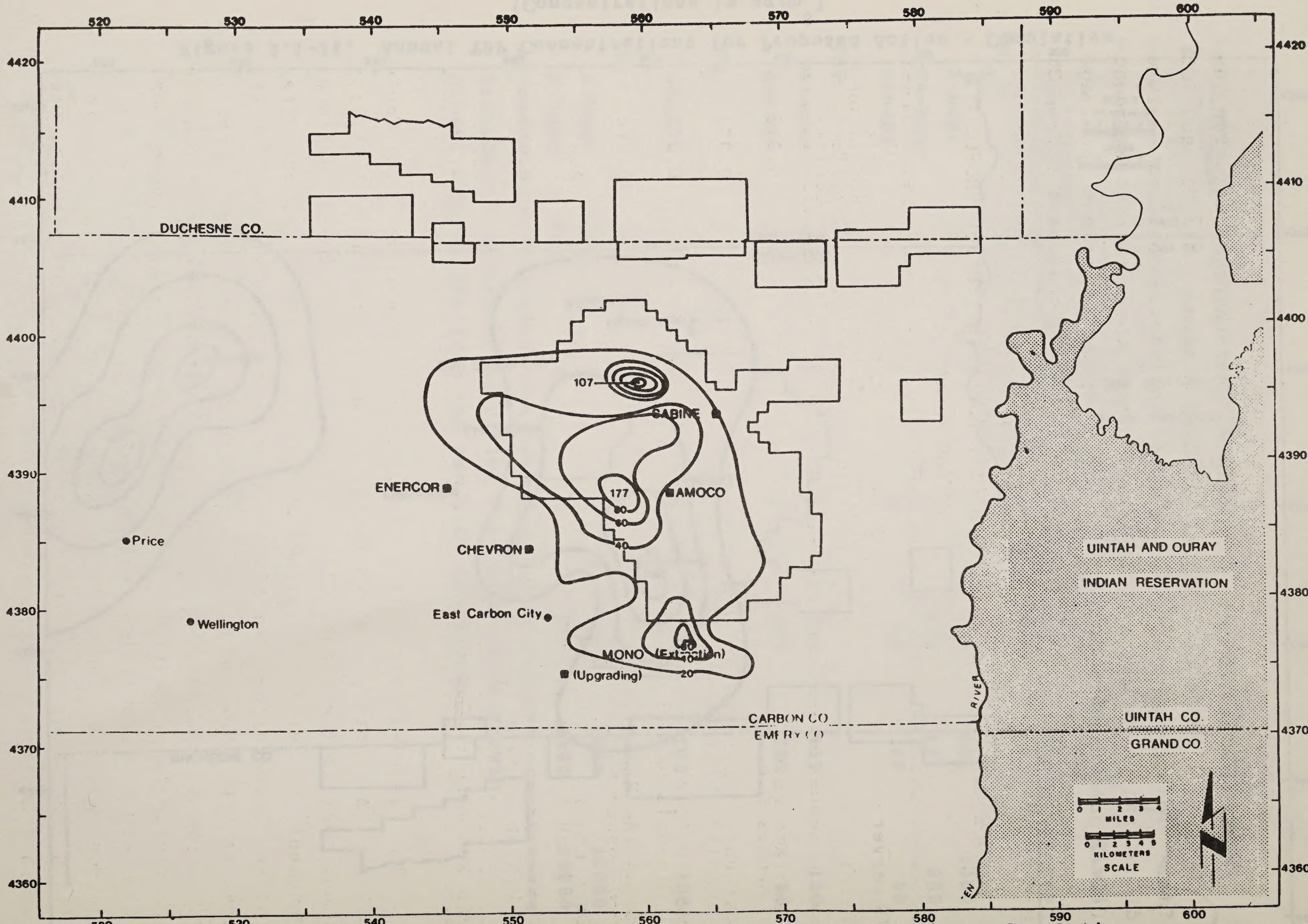

Figure 2.1-12. Annual NO_2 Concentrations for Proposed Action - Cumulative (Concentrations in ug/m^3)

Table 2.1-18 shows the level-1 screening results for the proposed action cumulative alternative. Notice that C1 and C2 fail for all observer points analyzed, that is, plume discoloration is perceptible regardless of the viewing background (i.e., dark terrain or blue sky). The SO_2 emissions are not sufficient to perceptibly contribute to regional haze (i.e., C3 passes level-1 screening).

TABLE 2.1-18. LEVEL-1 VISIBILITY ANALYSIS FOR THE PROPOSED ACTION - CUMULATIVE

Observer Point	C1 Plume Contrast Against Sky	C2 Plume Contrast Against Dark Terrain	C3 Region Reduction Sky/Terrain Contrast
Panorama Point, Arches N.P.	0.126	0.321	0.073
Cathedral Valley Overlook, Capitol Reef N.P.	0.106	0.231	0.073
Murray Point Overlook, Canyonlands N.P.	0.111	0.256	0.073
Moonshine Rapids, Dinosaur N.M.	0.118	0.283	0.073
Buck Knoll, Uintah & Ouray I.R.	0.175	0.604	0.073
Peters Point, Uintah & Ouray I.R.	0.190	0.712	0.073
EPA Recommended Guidelines	<0.100	<0.100	<0.100

The level-2 visibility results are summarized in Table 2.1-19. As noted, there would be no perceptible visibility impairment at the three Class I areas and Dinosaur National Monument. At Peter's Point and Buck Knoll of the Uintah and Ouray Indian Reservation, the plume may be perceptible against the sky due to the NOx emissions associated with the proposed development. Although at Buck Knoll particulate emissions may contribute to perceptible contrast and visual range reductions, it must be emphasized that the estimates given in Table 2.1-19 are conservative. The analysis assumed that all the emissions within the STSA, including those from ground level sources, were combined to form a single plume.

TABLE 2.1-19. LEVEL-2 VISIBILITY ANALYSIS FOR THE PROPOSED ACTION - CUMULATIVE

Observer Point	Contrast Reduction*	Visual Range Reduction (%)*	Blue-Red Ratio†
Panorama Point, Arches N.P.	0.039	3.8	0.98
Cathedral Valley Overlook, Capitol Reef N.P.	0.041	4.0	0.98
Murray Point Overlook, Canyonlands N.P.	0.044	4.3	0.94
Moonshine Rapids, Dinosaur N.M.	0.032	3.0	0.93
Buck Knoll, Uintah & Ouray I.R.	0.097	10.6	0.70
Peters Point, Uintah & Ouray I.R.	0.041	3.9	0.69
EPA Recommended Guidelines	<0.100	<11.0**	>0.90

* Wavelength = 0.55 um

** Visual range reduction criteria of 11% is calculated based on the EPA recommended contrast reduction criteria of 0.1 and an observer-terrain distance of 50 km.

† Blue/Red Ratio = [1+Contrast(0.4 um)]/[1+Contrast(0.7 um)]

Photochemical Smog

The photochemical reactions of emissions of reactive non-methane hydrocarbons and nitrogen oxides is a potential air quality concern because of the production of photochemical oxidants (mainly ozone). The impact of emissions from the proposed action and interrelated sources was analyzed by means of Version II of the Reactive Plume Model (RPM-II). Two trajectories were selected in the analysis, one traveling east toward Colorado, and the other traveling southeast toward Arches National Park.

The photochemical reaction was simulated following the movement of the plumes for 10 hours, from hour 0700 to hour 1700. This is the period of strongest solar radiation. All emissions from the facilities, mines, and spent tar sand areas in the Sunnyside STSA are assumed to be from a single point. This is a very conservative assumption because the hydrocarbons and nitrogen oxides will have sufficient initial concentrations to start photochemical reactions. Meteorological conditions were selected to represent a hypothetical worst-case event associated with a shallow mixing layer and low wind speed on a summer day. It has been shown by Holzworth (1972) that most of the episode days occur with afternoon mixing height between 1000 and 2000 meters and wind speed between 2 and 4 meters per second. An afternoon mixing height of 1000 meters was selected and since more than 100 kilometers traveling distance needed to be simulated, a wind speed of 4 m/s was chosen. The plume parcel travels about 150 km during the 10-hour simulation period. A worst-case summer morning mixing height of 250 meters in eastern Utah was used (Holzworth, 1972). Background concentrations of some of the photochemical species were obtain from the air quality data collected at U-a/U-b White River; others were derived from their associated urban values. The ambient concentrations of the hydrocarbon species do not have a significant effect on the results because most are less than their corresponding plume concentrations. Stability class B was used throughout the simulation period. Diurnal variation of the photolysis rate measured in Los Angeles (McRae, 1982) was adopted for use in the model. Although Los Angeles is located at a lower latitude, solar radiation is expected to be essentially the same as in eastern Utah.

Since the carbon-bond mechanism was adopted for the photochemical analysis, the emissions of olefin and aromatic classes of hydrocarbons are very important to the production of ozone. Unfortunately, an emission inventory of sufficient detail is not available. In the absence of this information, the non-reactive, but most abundant compound, methane, is initially removed from the total hydrocarbon emission using typical methane-total hydrocarbon ratio (Butcher and Charlson, 1972). The remaining hydrocarbon emissions were equally distributed among four major hydrocarbon groups - alkanes, alkenes, acetylenes, and aromatics.

Table 2.1-20 shows the results obtained using RPM-II and Figure 2.1-13 gives O_3 concentrations along the selected trajectories. As shown, for all areas of interest, the impact from the Sunnyside STSA does not exceed the ozone standard of 0.12 ppm (235 ug/m^3). It should be noted that the results are conservative because all Sunnyside emissions were treated as a single point source. Also, the lack of a detailed emission inventory of individual hydrocarbon compounds, especially those having high O_3 yields, such as terpines, toluene, ethene, propine, and 1-butene reflects the uncertainty of the results. A more refined photocemical smog impact analysis should be directed to estimate the emission rates of the above photochemical reactive species.

TABLE 2.1-20. SUMMARY OF RPM-II RESULTS FOR MAXIMUM PHOTOCHEMICAL PRODUCTS IN VARIOUS AREAS OF INTEREST

Species	O_3 (ppm)	NO (ppm)	PAN (ppm)	Aerosol (ug/m^3)
Maximum Concentration	0.11	0.042	0.0078	1.4
Uintah & Ouray I.R.	0.10	0.0064	0.0063	1.2
Arches National Park	0.10	0.0025	0.0056	1.4
Colorado Border	0.09	0.0025	0.0049	1.4

Acid Deposition

Unlike the visibility analysis, there is no EPA recommended guideline or procedure for determining potential impact of acid deposition to sensitive ecosystems. It has been widely accepted

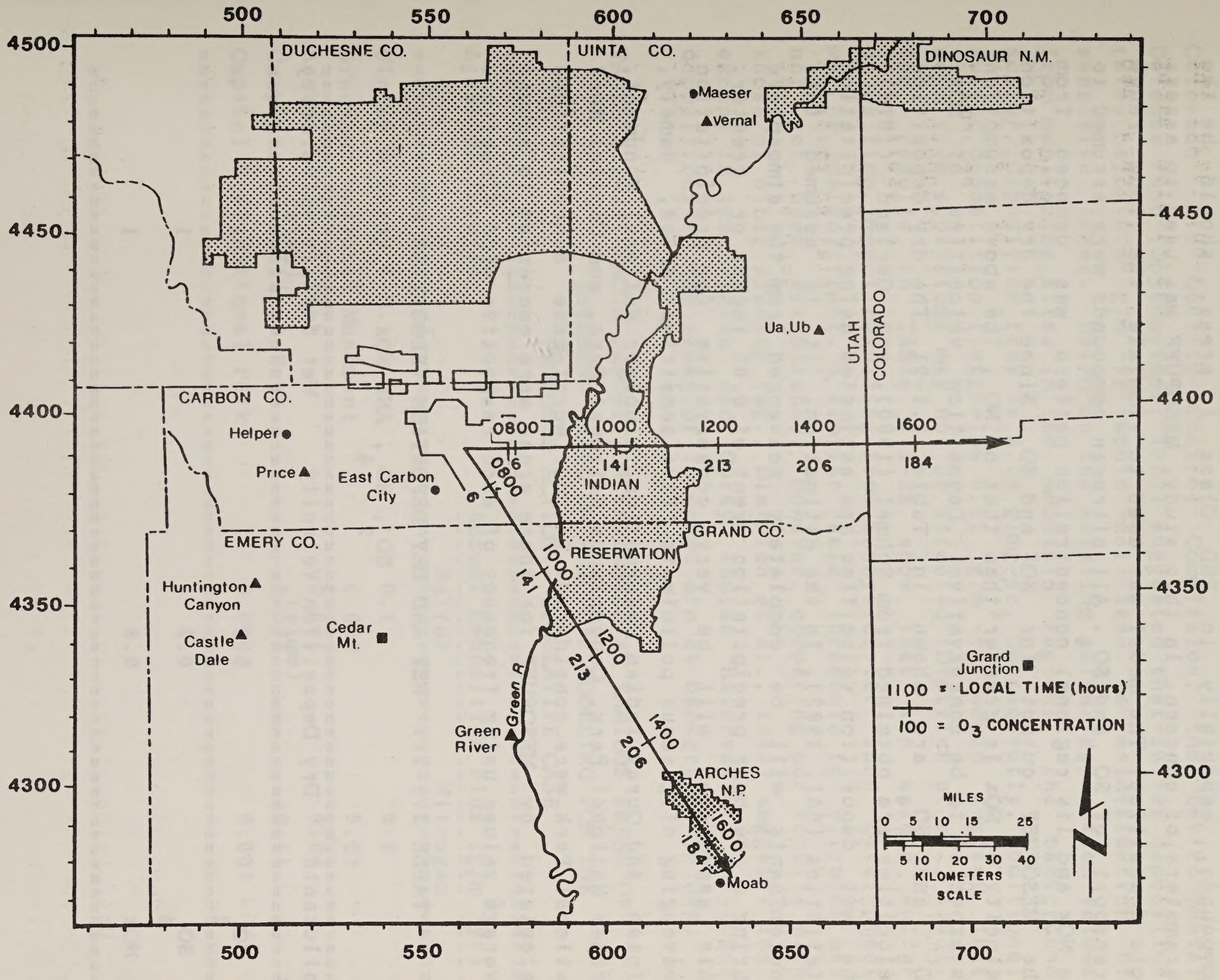

Figure 2.1-13. Trajectories Modeled for Worst-Case Photochemical Oxidant (Ozone) Impact

that SO_2 and NOx are the major precursors to acid deposition, therefore, the deposition fluxes of sulfur and nitrogen compounds, especially in PSD Class I areas, should be the parameters of concern. In this study, MESOPUFF was used to assess acid deposition. The model was used to simulate the long range transport of SO_2 and SO_4. All nitrogen compounds were assumed to be NOx and its regional concentration pattern was deduced from the MESOPUFF output for SO_2 and SO_4. Since the dry deposition velocity of NOx is greater than that of NO_3, the above assumption is expected to be conservative. Deposition velocities of NOx, SO_2, and SO_4 are shown in Table 2.1-21. The dry deposition velocities are obtained from Schmel (1980), and Garland (1976). The wet deposition velocities are estimated using precipitation statistics (SAI, 1983). In the estimation, it is assumed that contaminants will be completely scavenged from the atmosphere during a one-hour precipitation event of 0.01 inches or greater. This assumption will be very conservative for precipitation scavenging of gaseous pollutants. Five sensitive areas, namely, Uintah and Ouray Indian Reservation, Dinosaur National Monument, Arches National Park, Canyonlands National Park, and Capitol Reef National Park were considered. 24-hour worst-case concentrations calculated by MESOPUFF for these areas were converted to annual average values using frequency of each respective wind direction.

TABLE 2.1-21. WET AND DRY DEPOSTION VELOCITIES FOR SO_2, SO_4, AND NOx

Pollutants	Dry Deposition Velocity (cm/s)	Wet deposition Velocity (cm/s)
SO_2	0.8	1
SO_4	0.2	1
NOx	0.8	1

Table 2.1-22 presents the results of acid deposition analysis for all areas of interest. In a submitted testimony before the Colorado Air Quality Control Commission, the Environmental Defense Fund (Oppenheimer, 1982) suggested that sulfur deposition rates below 0.5 g/m^2-yr would not lead to acidification of sensitive lakes. Based on the existing sulfur deposition values from monitoring sites in the mountain regions, the background sulfur deposition flux is 0.28 g/m^2-yr. Consequently, additional sulfur depostition flux below 0.22 g/m^2-yr would suggest that sensitive ecosystems may not be affected (Dietrich et al., 1983). The results in Table 2.1-22 show that the acidic sulfur deposition impact resulting from Sunnyside tar sand development may be insignificant. A similar "safe" threshold for nitrogen has not yet been established. However, comparing our results with those of other studies (eg., Dietrich et al., 1983) suggests that except in the Uintah and Ouray Indian Reservation, nitrogen depositions in the areas of interest are at background values.

TABLE 2.1-22. ACID DEPOSITION ESTIMATES AT VARIOUS AREAS OF INTEREST BASED ON MESOPUFF MODELING FOR THE PROPOSED ACTION - CUMULATIVE CASE

Areas of Interest	Annual Deposition Flux (g/m^2-yr)	
	Sulfur	Nitrogen
Uintah & Ouray I.R.	0.1	0.8
Dinosaur National Monument	0.002	0.02
Arches National Park	0.005	0.04
Canyonlands National Park	0.001	0.01
Capitol Reef National Park	0.0004	0.003

2.2 PARTIAL CONVERSION ALTERNATIVE

2.2.1 Collective Impacts

Table 2.2-1 lists the maximum receptor concentrations compared to the NAAQS. Figures 2.2-1, 2.2-2, and 2.2-3 show the expected annual average TSP, SO_2, and NO_2 concentrations as a result of the partial conversion collective alternative.

NOx levels are estimated to be above the NAAQS due mostly to stack gas emissions. SO_2 impacts are also mainly due to stack gas emissions. The annual, 24-hour, and 3-hour Class II increments are estimated to be exceeded for SO_2. The stack gas impact is on elevated terrain near the projected facility. Locating the plant farther from high terrain and/or increasing the stack height would significantly reduce the estimated impact.

The high TSP levels are due to the assumed surface mining activities associated with the 75,000 BPD surface process. No known fugitive dust control measures are available that would fully mitigate the TSP impacts.

TABLE 2.2-1. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - PARTIAL CONVERSION COLLECTIVE

Pollutant	Source Category Contributions (ug/m^3)					
Ave. Time	2005 Baseline Sources	Inter-related Sources	Project Sources		Maximum Concen-tration	NAAQS
			Secondary	Direct		
SO_2						
3-hour	18	NA	0	1044	1062	1300
24-hour	7	NA	0	290	297	365
Annual	1	NA	0	22	23	80
TSP						
24-hour	62	NA	0	431	493	150
Annual	19	NA	0	108	127	60
NO_2						
Annual	2	NA	0	174	176	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

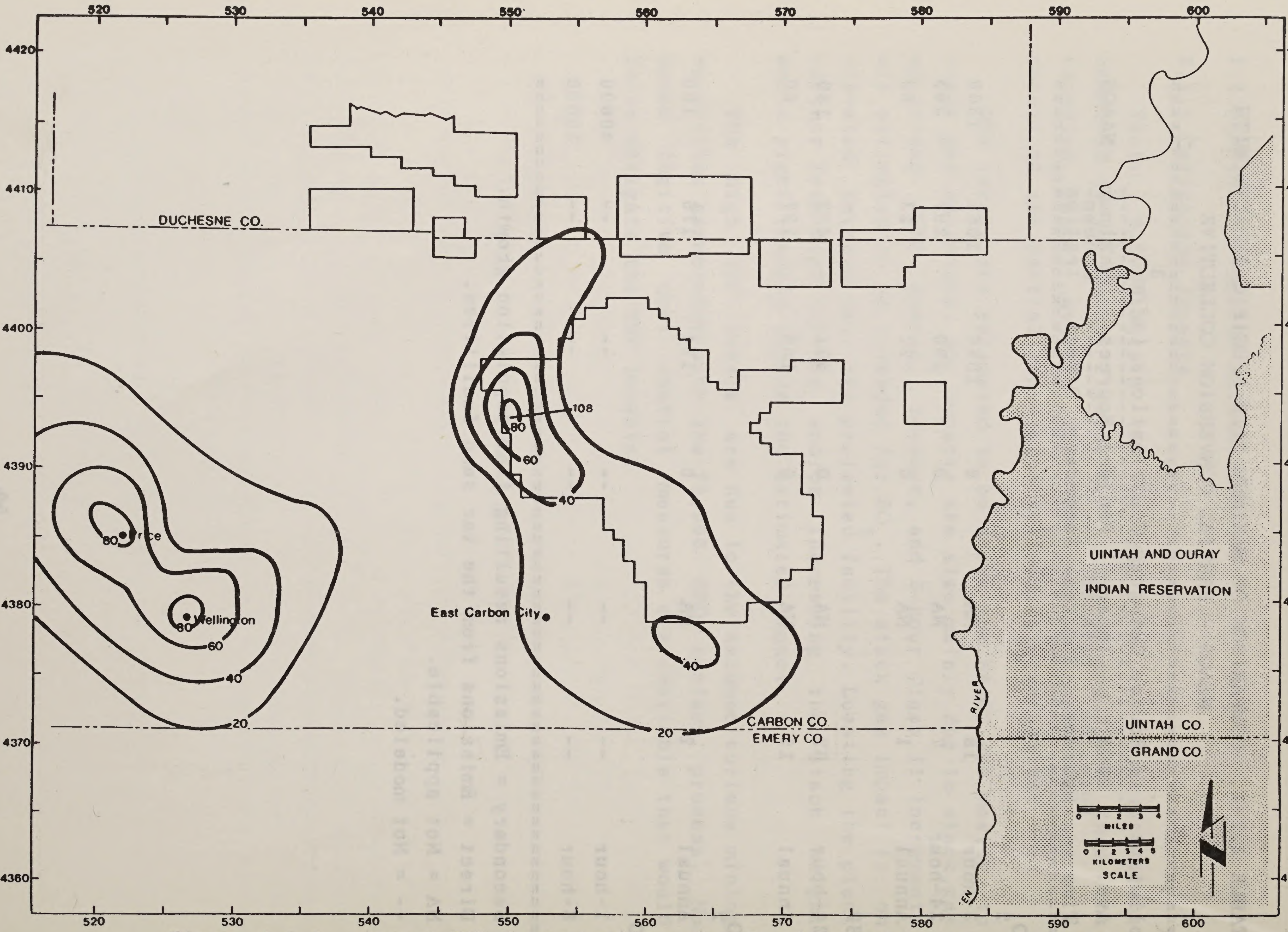

Figure 2.2-1. Annual TSP Concentrations for Partial Conversion - Collective (Concentrations in ug/m^3)

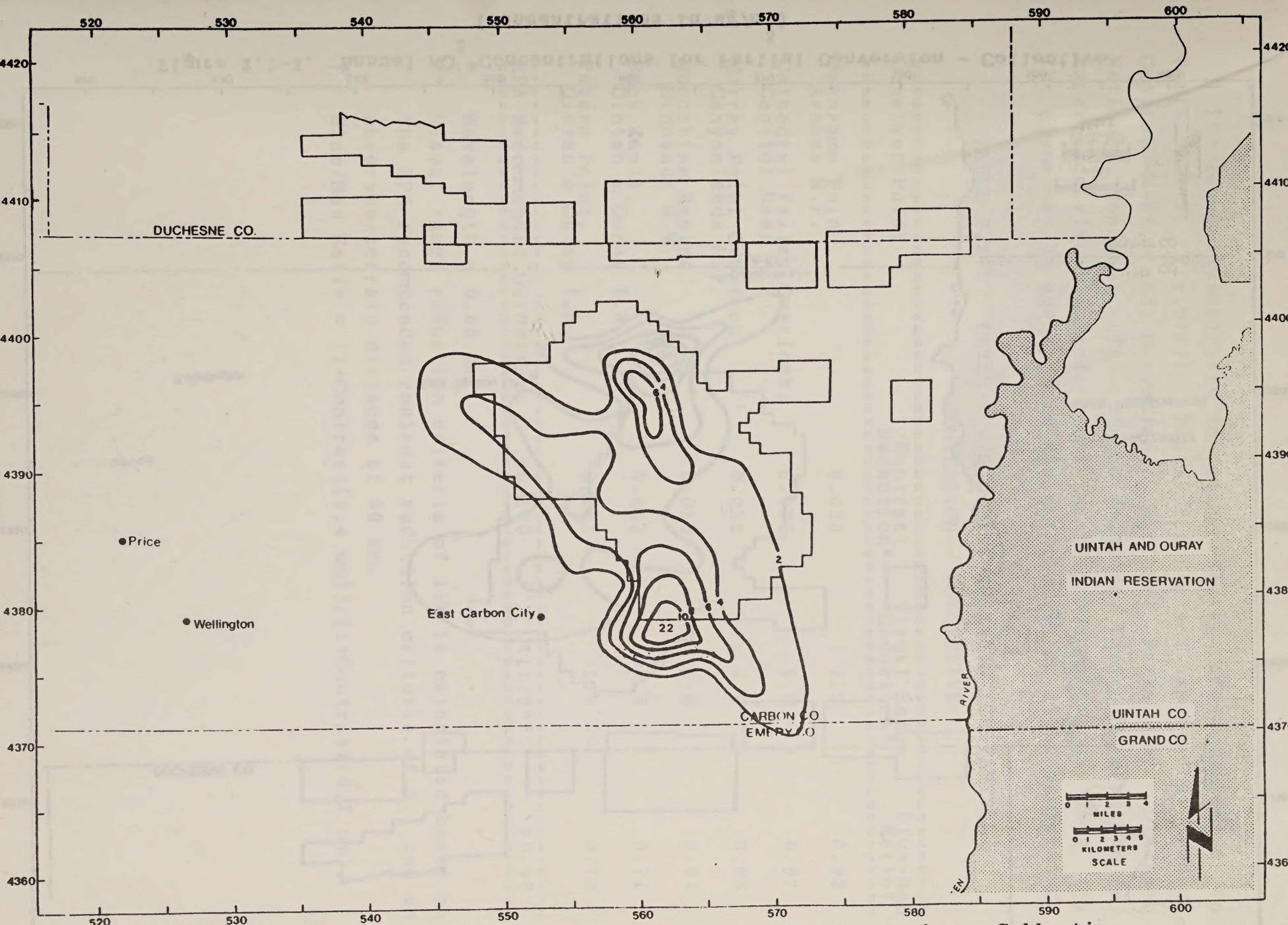

Figure 2.2-2. Annual SO_2 Concentrations for Partial Conversion - Collective (Concentrations in ug/m^3)

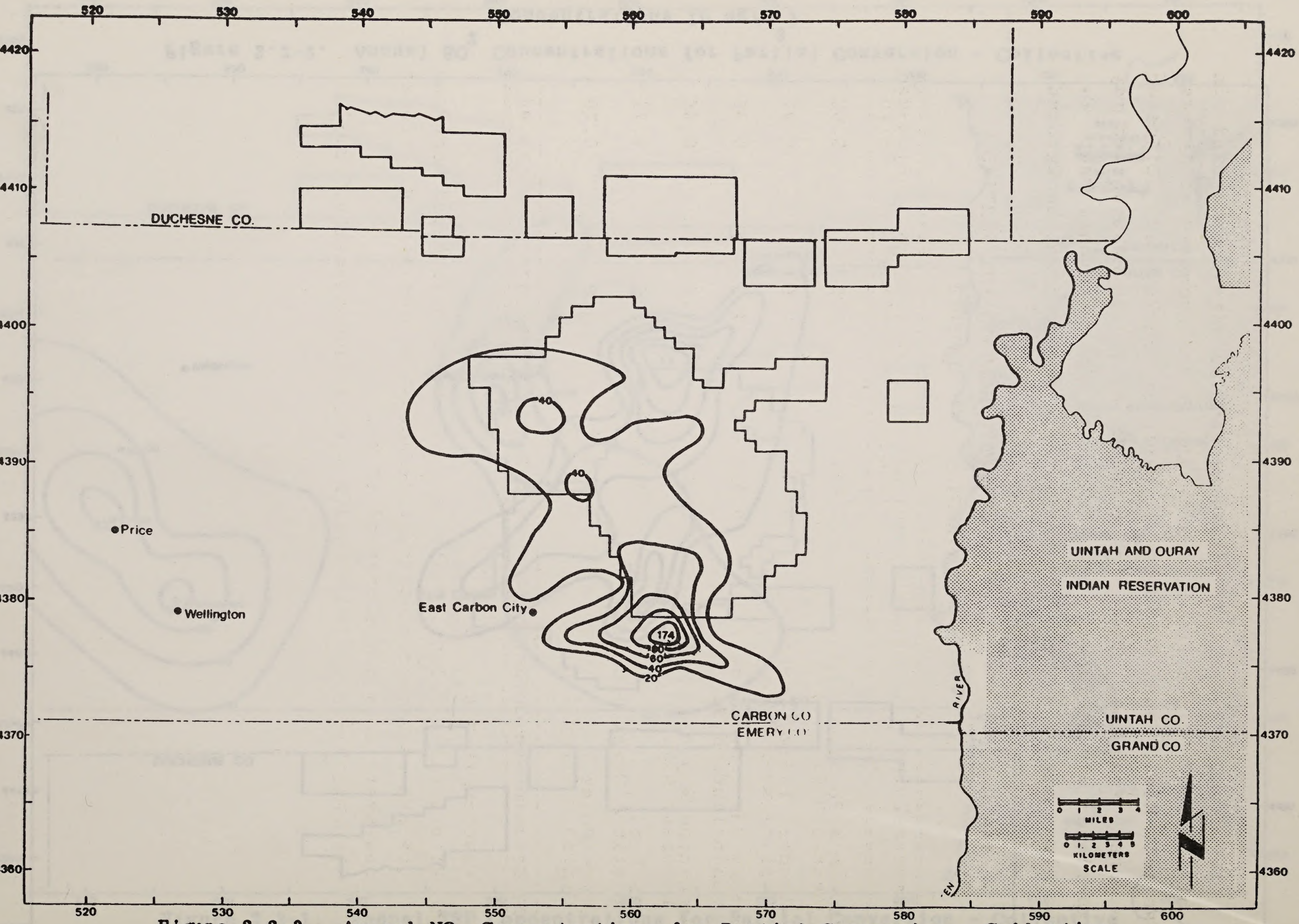

Figure 2.2-3. Annual NO_2 Concentrations for Partial Conversion - Collective (Concentrations in ug/m^3)

The level-2 visibility screening results are summarized in Table 2.2-2. Visibility impairment is not expected at Arches, Capitol Reef, and Canyonlands National Parks, or Dinosaur National Monument. The Uintah and Ouray Indian Reservation may experience visual impacts resulting from NOx emissions. That is, the plume may be perceptible against the sky or light background.

TABLE 2.2-2. LEVEL-2 VISIBILITY ANALYSIS FOR PARTIAL CONVERSION - COLLECTIVE

Observer Point	Contrast Reduction*	Visual Range Reduction*	Blue-Red Ratio†
Panorama Point, Arches N.P.	0.024	2.2	0.92
Cathedral Valley Overlook, Capitol Reef N.P.	0.021	2.0	0.97
Murray Point Overlook, Canyonlands N.P.	0.022	2.1	0.96
Moonshine Rapids, Dinosaur N.M.	0.018	1.6	0.94
Buck Knoll, Uintah & Ouray I.R.	0.053	5.3	0.71
Peters Point, Uintah & Ouray I.R.	0.021	1.9	0.70
EPA Recommended Guidelines	<0.100	<11.0**	>0.90

* Wavelength = 0.55 um

** Visual range reduction criteria of 11% is calculated based on the EPA recommended contrast reduction criteria of 0.1 and an observer-terrain distance of 50 km.

† Blue/Red Ratio = [1+Contrast(0.4 um)]/[1+Contrast(0.7 um)]

2.2.2 Cumulative Impacts

Table 2.2-3 lists the maximum impacts as compared to the NAAQS. The maximum values are essentially the same as for the collective impact but the general distribution of pollutants changes slightly. Figures 2.2-4, 2.2-5, and 2.2-6 show the expected annual average TSP, SO_2, and NO_2 cumulative impacts.

NO_2 levels are estimated to be above the NAAQS due mostly to stack gas emissions. The PSD Class II increments are expected to be exceeded for TSP and for SO_2 in a small area of elevated terrain as in the collective scenario.

TABLE 2.2-3. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - PARTIAL CONVERSION CUMULATIVE

Pollutant	Source Category Contributions (ug/m^3)					
Ave. Time	2005 Baseline Sources	Inter-related Sources	Project Sources		Maximum Concentration	NAAQS
			Secondary	Direct		
SO_2						
3-hour	18	0	0	1044	1062	1300
24-hour	7	0	0	290	297	365
Annual	1	<1	0	22	23	80
TSP						
24-hour	62	0	0	431	493	150
Annual	19	0	0	108	127	60
NO_2						
Annual	2	1	0	174	177	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

-- = Not modeled.

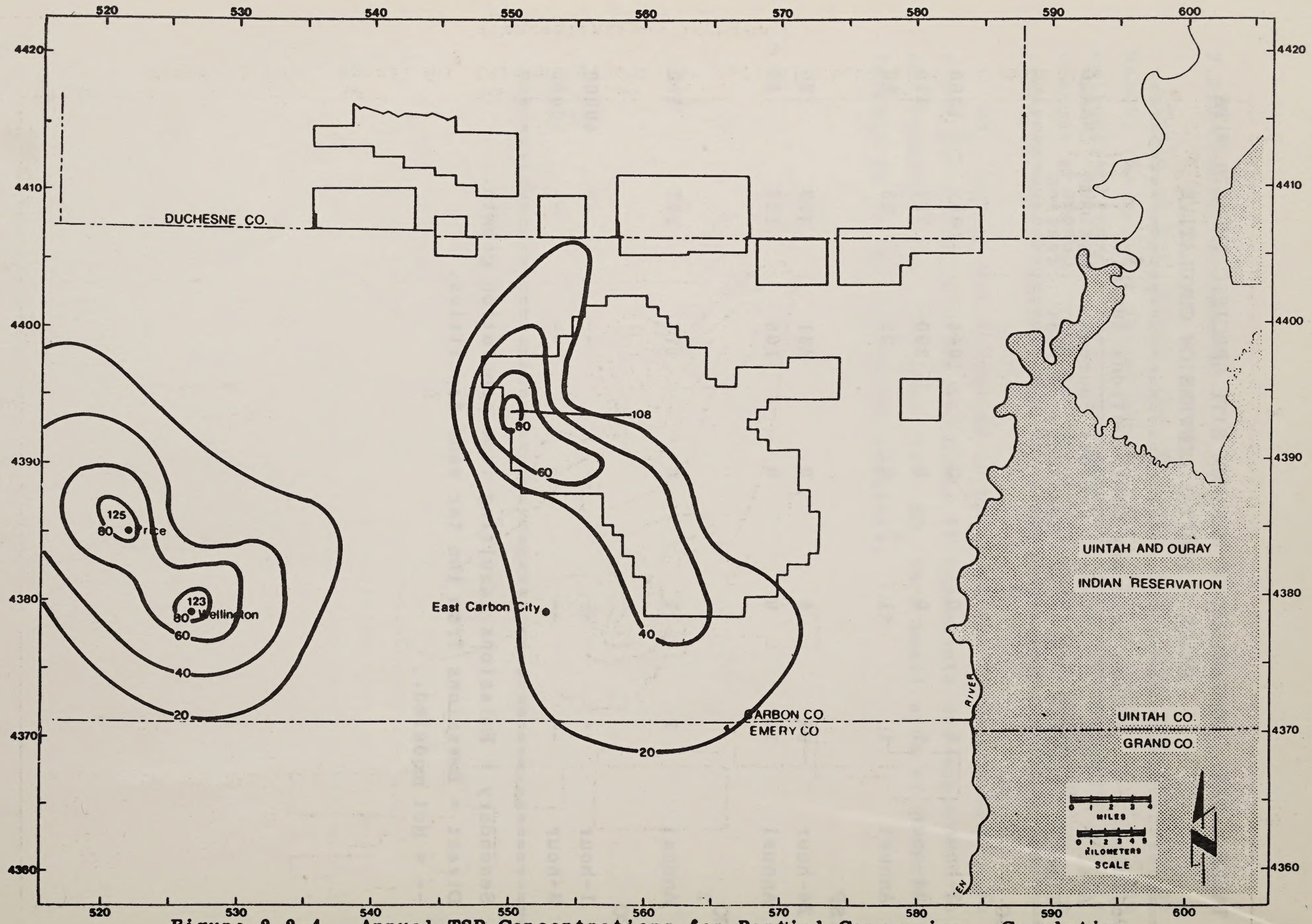

Figure 2.2-4. Annual TSP Concentrations for Partial Conversion - Cumulative (Concentrations in ug/m^3)

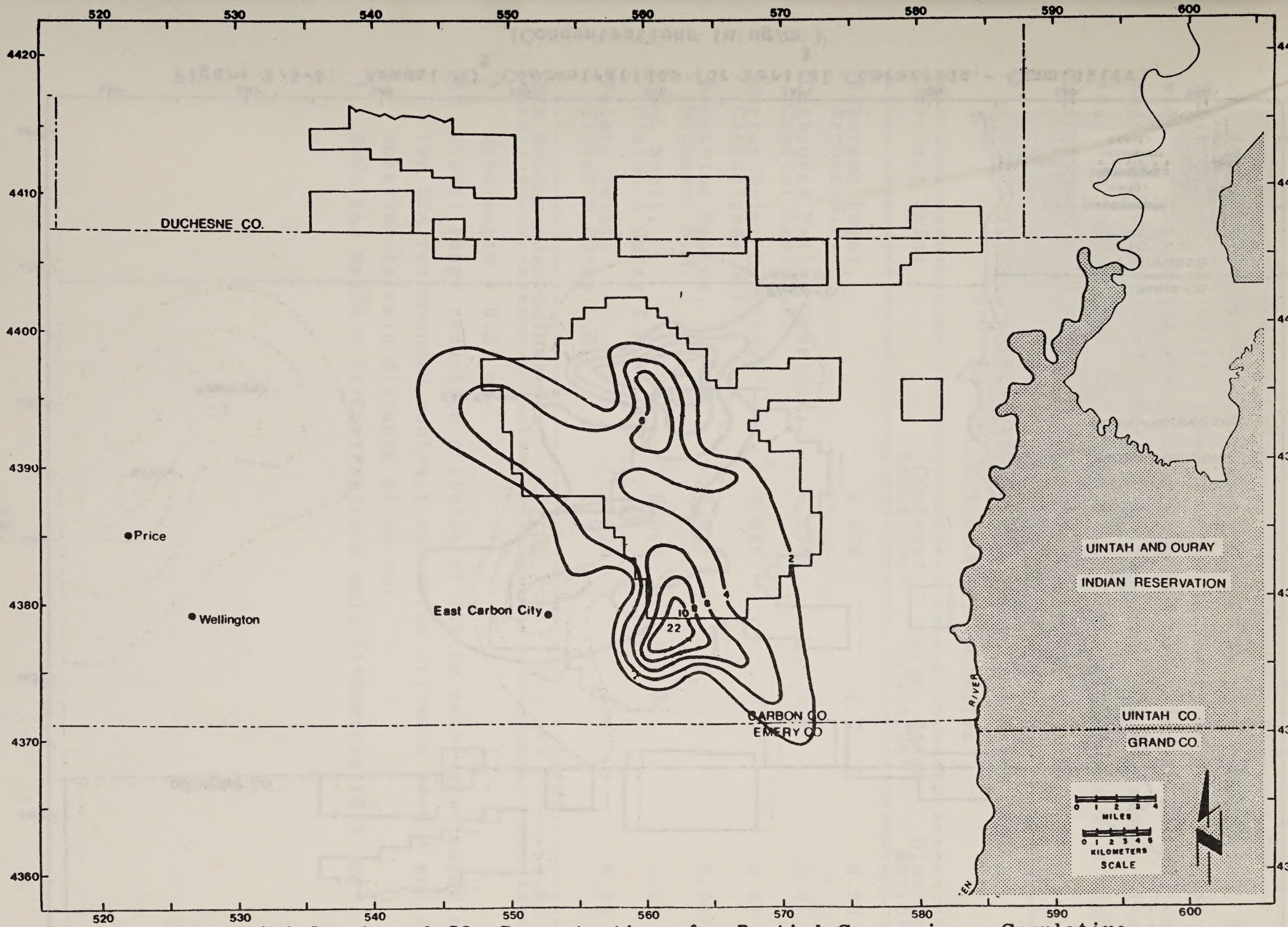

Figure 2.2-5. Annual SO_2 Concentrations for Partial Conversion - Cumulative

(Concentrations in ug/m^3)

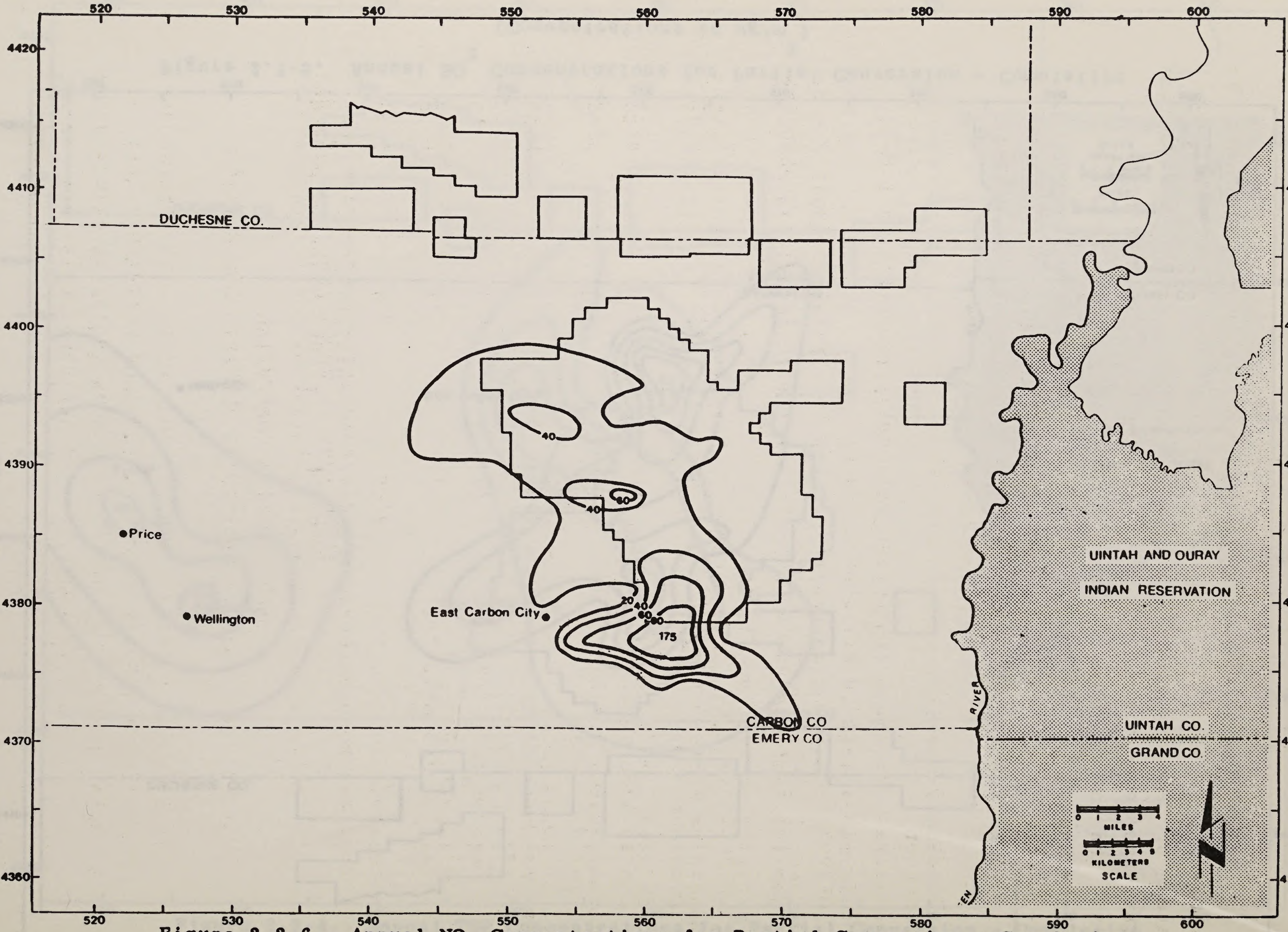

Figure 2.2-6. Annual NO_2 Concentrations for Partial Conversion - Cumulative (Concentrations in ug/m^3)

The level-2 visibility screening results are summarized in Table 2.2-4. Visibility impairment is not expected at any Class I area or Category I area. The Uintah and Ouray Indian Reservation may experience visual impacts resulting from NOx emissions. That is, the plume may be perceptible against the sky or a light background.

TABLE 2.2-4. LEVEL-2 VISIBILITY ANALYSIS FOR THE PARTIAL CONVERSION - CUMULATIVE

Observer Point	Contrast Reduction*	Visual Range Reduction*	Blue-Red Ratio†
Panorama Point, Arches N.P.	0.029	2.7	0.92
Cathedral Valley Overlook, Capitol Reef N.P.	0.025	2.4	0.97
Murray Point Overlook, Canyonlands N.P.	0.027	2.5	0.96
Moonshine Rapids, Dinosaur N.M.	0.021	1.9	0.93
Buck Knoll, Uintah & Ouray I.R.	0.064	6.5	0.69
Peters Point, Uintah & Ouray I.R.	0.025	2.4	0.69
EPA Recommended Guidelines	<0.100	<11.0**	>0.90

* Wavelength = 0.55 um

** Visual range reduction criteria of 11% is calculated based on the EPA recommended contrast reduction criteria of 0.1 and an observer-terrain distance of 50 km.

† Blue/Red Ratio = [1+Contrast(0.4 um)]/[1+Contrast(0.7 um)]

2.3 UNITIZED DEVELOPMENT ALTERNATIVE

2.3.1 Collective Impacts

Table 2.3-1 lists the maximum impacts compared to the NAAQS. Except for TSP, the NAAQS are not expected to be exceeded. Figure 2.3-1 shows the expected annual average TSP collective impact for the unitized development alternative.

The PSD Class II increment will be exceeded for TSP over a large area due to the surface mining activities of the projected 50,000 BPD facility. No known fugitive dust control measures are sufficient to fully mitigate the TSP impacts.

The SO_2 24-hour PSD increment will be exceeded due to stack gas emissions impacting elevated terrain. The area involved is small and the impact can be mitigated in several ways.

TABLE 2.3-1. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - UNITIZED DEVELOPMENT COLLECTIVE

Pollutant Ave. Time	Source Category Contributions (ug/m^3) 2005 Baseline Sources	Inter-related Sources	Project Sources Secondary	 Direct	Maximum Concentration	NAAQS
SO$_2$						
3-hour	18	NA	0	312	330	1300
24-hour	7	NA	0	120	127	365
Annual	1	NA	0	12	13	80
TSP						
24-hour	148	NA	15	581	744	150
Annual	40	NA	4	145	189	60
NO$_2$						
Annual	2	NA	0	63	65	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

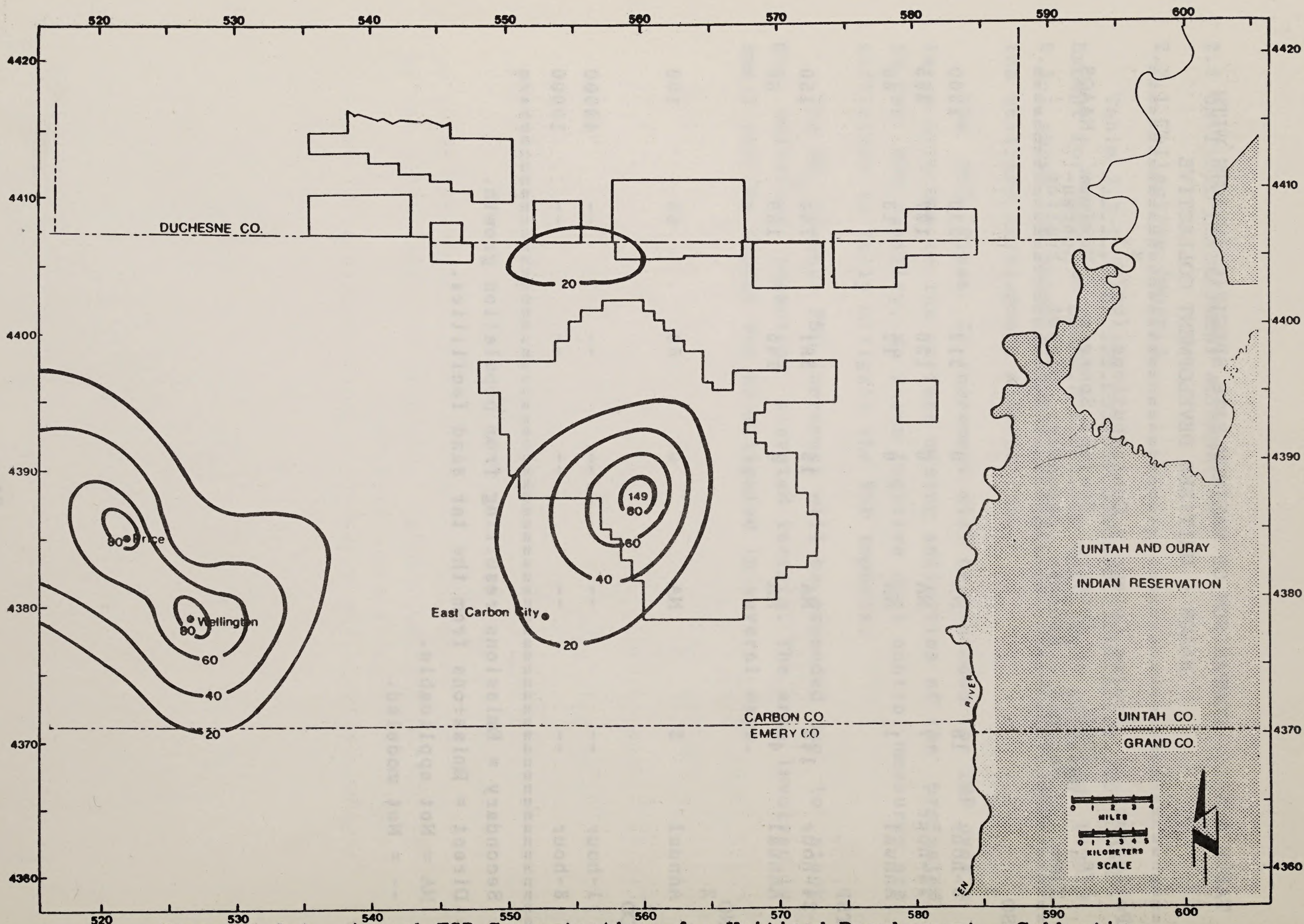

Figure 2.3-1. Annual TSP Concentrations for Unitized Development - Collective (Concentrations in ug/m^3)

The level-2 visibility screening results are summarized in Table 2.3-2. Visibility impairment is not expected at Arches, Capitol Reef, and Canyonlands National Parks, or Dinosaur National Monument. The Uintah and Ouray Indian Reservation may experience visual impacts resulting from NOx emissions. That is, the plume may be perceptible against the sky or light background.

TABLE 2.3-2. LEVEL-2 VISIBILITY ANALYSIS FOR UNITIZED DEVELOPMENT - COLLECTIVE

Observer Point	Contrast Reduction*	Visual Range Reduction*	Blue-Red Ratio†
Panorama Point, Arches N.P.	0.019	1.8	0.97
Cathedral Valley Overlook, Capitol Reef N.P.	0.017	1.6	0.99
Murray Point Overlook, Canyonlands N.P.	0.018	1.7	0.99
Moonshine Rapids, Dinosaur N.M.	0.014	1.3	0.97
Buck Knoll, Uintah & Ouray I.R.	0.048	4.7	0.85
Peters Point, Uintah & Ouray I.R.	0.018	1.7	0.85
EPA Recommended Guidelines	<0.100	<11.0**	>0.90

* Wavelength = 0.55 um

** Visual range reduction criteria of 11% is calculated based on the EPA recommended contrast reduction criteria of 0.1 and an observer-terrain distance of 50 km.

† Blue/Red Ratio = [1+Contrast(0.4 um)]/[1+Contrast(0.7 um)]

2.3.2 Cumulative Impacts

Table 2.3-3 lists the maximum impacts as compared to the NAAQS. Figure 2.3-2 shows the expected annual average TSP cumulative impact of the unitized development alternative. Except for TSP, no NAAQS are expected to be violated. The maximum values as well as the general impacted area increases over the collective impacts.

The Class II PSD increments will be exceeded in a large area for TSP. No control measures are known that would fully mitigate the predicted impacts.

SO_2 Class II PSD increments are expected to be exceeded for the cumulative impacts. As with the collective impacts, the SO_2 impacts can be mitigated in several ways.

TABLE 2.3-3. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - UNITIZED DEVELOPMENT CUMULATIVE

Pollutant	Source Category Contributions (ug/m^3)					
Ave. Time	2005 Baseline Sources	Inter-related Sources	Project Sources		Maximum Concentration	NAAQS
			Secondary	Direct		
SO_2						
3-hour	18	NA	0	374	392	1300
24-hour	7	NA	0	144	151	365
Annual	1	NA	0	14	15	80
TSP						
24-hour	148	NA	15	696	859	150
Annual	40	NA	4	174	218	60
NO_2						
Annual	2	NA	0	75	77	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

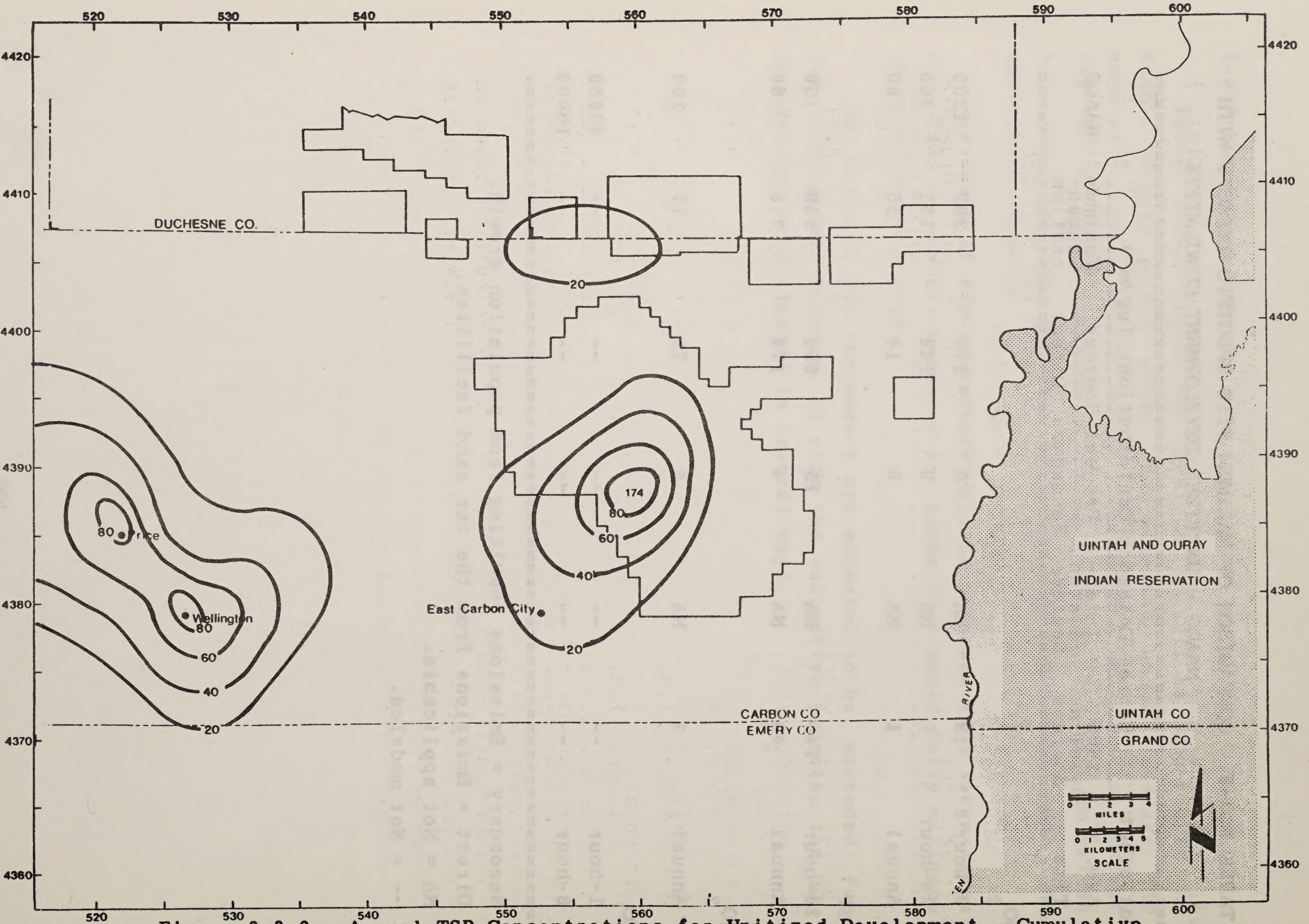

Figure 2.3-2. Annual TSP Concentrations for Unitized Development - Cumulative (Concentrations in ug/m^3)

The level-2 visibility screening results are summarized in Table 2.3-4. Visibility impairment is not expected at any Class I or Category I area. The Uintah and Ouray Indian Reservation may experience visual impacts resulting from NOx emissions. That is, the plume may be perceptible against the sky or light background.

TABLE 2.3-4. LEVEL-2 VISIBILITY ANALYSIS FOR UNITIZED DEVELOPMENT - CUMULATIVE

Observer Point	Contrast Reduction*	Visual Range Reduction*	Blue-Red Ratio†
Panorama Point, Arches N.P.	0.023	2.1	0.97
Cathedral Valley Overlook, Capitol Reef N.P.	0.021	1.9	0.99
Murray Point Overlook, Canyonlands N.P.	0.022	2.1	0.99
Moonshine Rapids, Dinosaur N.M.	0.017	1.5	0.96
Buck Knoll, Uintah & Ouray I.R.	0.057	5.7	0.83
Peters Point, Uintah & Ouray I.R.	0.021	2.0	0.83
EPA Recommended Guidelines	<0.100	<11.0**	>0.90

* Wavelength = 0.55 um

** Visual range reduction criteria of 11% is calculated based on the EPA recommended contrast reduction criteria of 0.1 and an observer-terrain distance of 50 km.

† Blue/Red Ratio = [1+Contrast(0.4 um)]/[1+Contrast(0.7 um)]

2.4 NO ACTION ALTERNATIVE

The no action alternative includes the county-wide particulate emission sources from the 1981 inventory increased proportionally by the expected population growth. Also included in this alternative is the 10,000 BPD Chevron private mine and facility.

Table 2.4-1 lists the maximum impacts from the Chevron development as compared to the NAAQS. Figure 2.4-1 shows the expected annual average TSP levels for the no action scenario. As shown, the area near Price and Wellington is expected to be above the NAAQS. Also, a small area centered on the projected tar sand surface mine is also expected to be above the NAAQS. The highest TSP concentration has an annual average value of 118 ug/m^3 and a 24-hour value of 458 ug/m^3.

TABLE 2.4-1. COMPARISON OF MAXIMUM SITE SPECIFIC IMPACTS WITH NAAQS - NO ACTION ALTERNATIVE

Pollutant Ave. Time	Source Category Contributions (ug/m^3) 2005 Baseline Sources	 Inter-related Sources	 Project Sources Secondary	 Direct	Maximum Concentration	NAAQS
SO_2						
3-hour	18	NA	0	126	144	1300
24-hour	7	NA	0	35	42	365
Annual	1	NA	0	3	4	80
TSP						
24-hour	148	NA	0	154	302	150
Annual	40	NA	0	39	79	60
NO_2						
Annual	2	NA	0	49	51	100
CO						
1-hour	--	--	--	--	--	40000
8-hour	--	--	--	--	--	10000

Secondary = Emissions resulting from population growth.

Direct = Emissions from the tar sand facilities.

NA = Not applicable.

-- = Not modeled.

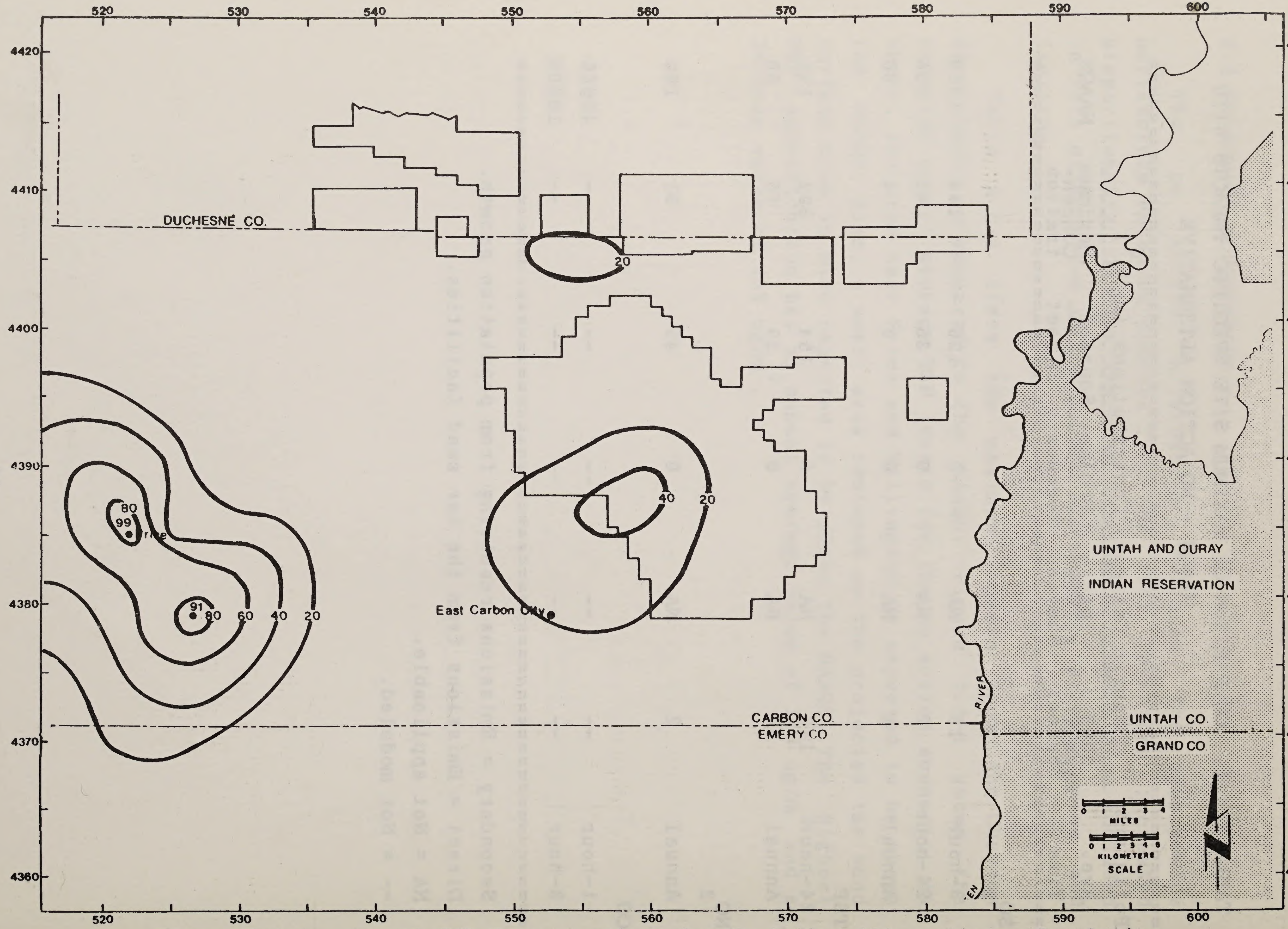

Figure 2.4-1. Annual TSP Concentrations for No Action Alternative - Cumulative (Concentrations in ug/m^3)

3. METHODOLOGIES

3.1 EMISSION INVENTORY METHODOLOGY

3.1.1 Description of Tar Sand Facilities and Their Impact on Air Emissions

Two tar sand recovery methods are being considered in Utah: surface mining with surface extraction; and in situ recovery (see Figure 3.1-1). Underground mining is not at this time economically feasible for Utah tar sand resources since the tar sands are mostly soft and friable; a large portion of the material would have to be left underground to support the overburden. This section describes tar sand resource recovery technology with emphasis on those processes that produce air pollution emissions. Later sections will outline the emission estimation methodologies and will present the air emissions for all sources considered in the impact evaluation. Portions of the following discussion were excerpted from Daniels et al., 1981.

3.1.1.1 Surface Mining and Extraction

Surface Mining

Open pit or strip-mining techniques may be used to excavate the tar sand deposit for several of the projects. Most of the emissions from surface mining activities involve pollutants generated by the following operations and processes:

- drilling and blasting,
- overburden removal,
- loading and dumping of overburden, tar sand, and spent tar sand,
- haul and access road traffic, and
- wind erosion from disturbed surfaces.

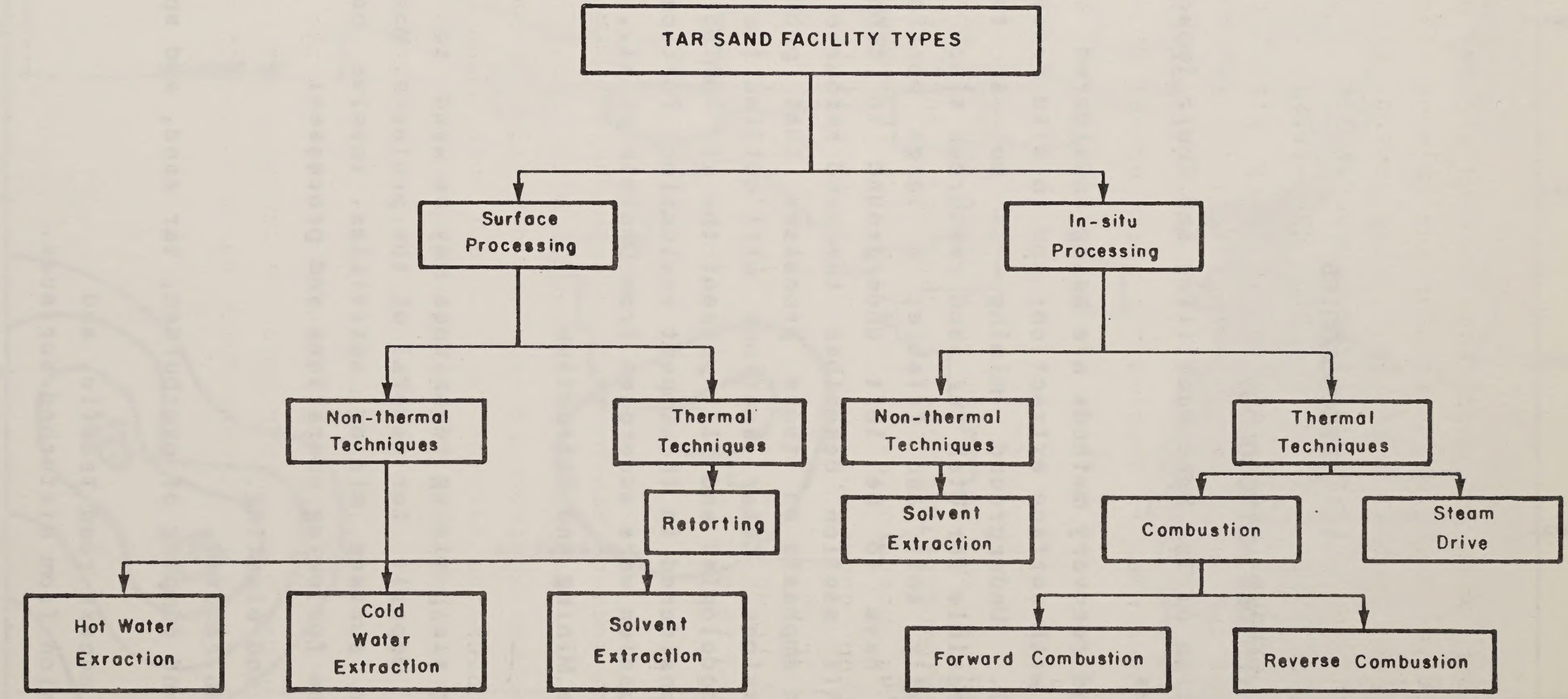

Figure 3.1-1. Tar Sand Recovery Methods

Haul roads along with unpaved access roads are the principal source of fugitive dust at most surface mining facilities. Emission factors, control strategies, and control efficiencies for fugitive dust sources are well documented in the literature (U.S. EPA Region VIII, 1979 and U.S. EPA, 1979). Vehicle and heavy equipment exhaust emissions can be very significant for surface mining of tar sand, as approximately 100 tons of tar sand has to be mined for every 7 tons of bitumen extracted. Thus, a large amount of material is handled for every barrel of synthetic crude produced.

Extraction by Retorting

In this process, thermal decomposition is used to extract oil from tar sands. Temperatures between 900 and 1200° F in the retort apparatus produce gases and solid coke from the bitumen. The gases are then condensed producing a fuel with a lower average molecular weight, sulfur content, and carbon-to-hydrogen ratio than the bitumen. None of the projects in the Sunnyside STSA are expected to use surface retorting.

Solvent Extraction

A petroleum solvent can be used to wash the bitumen from its consolidated sand matrix. The solvent, with the dissolved bitumen, is separated from the sand and distilled to remove the bitumen and recover the solvent for further use. The solvents most often mentioned for this procedure are benzene and toluene. An auxiliary boiler is used for the combustion of the residual vapors from the distillation process and is expected to be the primary source of gaseous emissions. Storage tanks at the facility are minor hydrocarbon emission sources when controlled with vapor recovery systems. Mono Power has proposed this type of recovery method.

Hot Water Extraction

Hot water extraction is currently being used in Canada on a commercial basis. The tar sands are agitated in hot water that is slightly basic. The hot water causes the water film around the bitumen to swell and permits the bitumen to float away. This method is most effective with tar sands that have a water film between the bitumen and its matrix (i.e., water-wet tar sands). Most of the Utah tar sands are not water-wet.

Cold Water Extraction

Cold water extraction is a variation of hot water extraction using water-wet tar sands and involves mechanical and chemical separation of the bitumen from the tar sand. In particular, a solvent, cold water, and reagents, such as soda ash, are combined with physical agitation, clarification, and thickening to separate bitumen from the tar sand ore. No projects in this study are expected to use this technique.

3.1.1.2 In Situ Extraction

Steam Injection

Steam-drive procedures involve continuous injection of high-temperature steam to mobilize the tar sand bitumen for collection in a set of wells surrounding the steam-injection well. An emulsion of petroleum and water is pumped to the surface by standard oil-field pumping procedures. Separation techniques, such as gravity settling and de-emulsifying agents, are used to produce product oil and water for re-use in the process. The most significant emissions will come from the stack gas of the steam generator. Additionally, fugitive emissions from land movement activities and exhaust gas emissions from vehicle operation can be expected. Sabine is proposing an in situ steam injection recovery operation.

Combustion

In situ combustion techniques are designed to reduce the viscosity of the bitumen and then mobilize the resulting fluids for collection at a production well. Combustion is initiated in the tar sand formation and the heat generated volatilizes the water and light hydrocarbons in the bitumen. Injected air serves as both the driving force for the production fluids and the oxygen source for combustion.

In forward combustion, a fire is ignited in the tar sand formation at the air injection well. The mobilized bitumen moves ahead of the flame, being driven by the compressed air, and is brought to the surface in a production well.

The reverse combustion process involves igniting the burn front at the production well and injecting compressed air at the injection well. The burn front volatilizes the bitumen as it moves from the production well toward the injection well, while the compresssed air drives the volatilized hydrocarbons through the hot burned-out zone toward the production well.

In addition to significant emissions of the criteria pollutants, large quantities of carbon dioxide, ethylene, ethane, propylene, propane, carbonyl sulfide, hydrogen sulfide, and ammonia emissions may potentially be emitted if not controlled (McDonald, 1977). None of the projects in the Sunnyside STSA are expected to use in situ combustion.

3.1.2 Methodologies used in Estimating Emissions from Proposed Facilities

3.1.2.1 General

Several sources of information were utilized to develop the emission inventory for the proposed facilities. The primary sources of specific project information were estimates provided by the developers. These estimates were given in various degrees of detail and in different formats. A very detailed plan of operation was provided by Mono Power for their proposed surface mine, solvent extraction, and upgrading facilities. However, the emission information available for Chevron consisted of a BLM-supplied questionnaire giving only total pollutant emissions with no indication as to how the emissions were calculated. The second source of specific project emissions were previous environmental impact evaluations. Most often used was the Air Quality Technical Report for the Uintah Basin Synfuels Development (SAI, 1983). The amount of detail provided by these impact reports also varied but were normally quite adequate.

For those projects with no estimates provided by the developers or those for which no estimates were found in other impact reports, Aerocomp calculated the emissions based upon:

- published emission factors,
- emissions from similar facilities, and/or
- process emissions discussed in the literature.

3.1.2.2 Vehicle Exhaust and Fugitive Dust Emissions

Tables 3.1-1 and 3.1-2 list the emission factors and assumed controls for vehicle exhaust and fugitive dust emissions, respectively. The activity rates vary primarily with the type of operation (i.e., surface or in situ), the daily production rate, and the location of the various facilities. Aerocomp developed activity factors based upon plans of operation for each type of tar sand facility. The most used reference for the activity factor was the Mono Power Plan of Operation, April 19, 1983. When no other information was provided by the developer, the emission factors and the assumed activity rates were used to develop the specific project inventory for vehicle exhaust and fugitive dust emissions.

3.1.2.3 Facility Emissions

Facility emissions provided by the developers were used whenever possible. The next section gives a reference for each specific project's estimation procedure. The following general

TABLE 3.1-1. EMISSION FACTORS USED FOR VEHICLE EXHAUST EMISSIONS CALCULATIONS

Source	Emission Factors*			
	SOx	NOx	CO	TSP
Scraper Operations	0.901	12.1	2.84	0.789
Drilling	0.932	14.8	2.82	0.902
Overburden Removal-FEL	0.857	11.2	2.62	0.805
Overburden Haul	0.887	14.9	2.62	0.502
Tar Sand Removal-FEL	0.857	11.2	2.62	0.805
Tar Sand Haul	0.887	14.9	2.62	0.502
Tailings Haul	0.887	14.9	2.62	0.502
Tailings Pile Maintenance	0.867	12.5	1.83	0.411
Reclamation	0.874	10.5	2.19	0.625
Road Maintenance	0.874	10.5	2.19	0.625
Water Truck	0.887	14.9	2.62	0.502
Access Road Vehicles*	1.470	2.53	17.93	1.40
Other Diesel Vehicles	0.932	14.8	2.82	0.902
Other Gasoline Vehicles*	0.130	2.51	76.4	3.16

* All values are grams/horsepower-hour except for starred sources, which are grams/vehicle-mile.

REFERENCES:

[1] U.S. Environmental Protection Agency. 1979. Compilation of Air Pollution Emission Factors. AP-42. Third Edition, Research Triangle Park, N.C.

[2] U.S. Environmental Protection Agency. 1981. User's Guide to MOBILE2 (Mobile Source Emissions Model). EPA-460/3-81-006, 2565 Plymouth Road, Ann Arbor, MI.

TABLE 3.1-2. FUGITIVE DUST EMISSION FACTORS, CONTROL STRATEGIES, AND CONTROL EFFICIENCIES

Source	Emission factor	Control strategy	Efficiency (%)	Reference
Mining Operations				
Scraper operations	16 lbs/scraper-hrs	--	--	1
Drilling	1.5 lbs/hole	--	--	1
Blasting	49.8 lbs/blast	--	--	1
Overburden removal	0.037 lbs/ton	--	--	1
Overburden haul	5 lbs/VMT	watering watering and tar sand	50 70	1
Overburden dumping	0.031 lbs/ton	--	--	2
Tar sand removal	0.037 lbs/ton	*	80	1
Tar sand haul	5 lbs/VMT	watering water and tar sand	50 70	1
Tar sand dumping	0.031 lbs/ton	*	80	2
Conveying	0.2 lbs/ton	vent to bag house	99	1
Tar sand crushing & screening	0.002 lbs/ton	vent to bag house	99	1
Grader operations	32 lbs/grader-hr	--	--	1
Wind erosion -- disturbed areas	1600 lbs/acre-yr	--	--	2
Access roads	5 lbs/VMT	watering watering and tar sand	50 70	1
Spent Tar Sand Operations				
Tailings haul	5 lbs/VMT	watering watering and tar sand	50 70	1
Tailings dumping	0.001 lbs/ton	--	--	2
Grader operations	32 lbs/grader-hr	--	--	1
Wind erosion -- disturbed areas	1600 lbs/acre-yr	--	--	2
Access roads	5 lbs/VMT	watering watering and tar sand	50 70	1

* Oily nature of tar sands acts as a chemical dust suppressant.

VMT = Vehicle miles traveled

[1] U.S. Environmental Protection Agency, Region VIII. 1979. Region VIII Interim Policy Paper on the Air Quality Review of Surface Mining Operations. Denver, CO.

[2] Colorado Air Pollution Control Division. 1981. Fugitive Dust Emissions.

assumptions were used depending upon the type of facility.

- Solvent extraction and upgrading - assumed emissions similar to those of Mono Power facilities, which basically use coal and coke as fuels and wet cyclones and FGD systems for stack emission controls.
- Hot water extraction and upgrading - emission rates are based upon other impact evaluation reports and assume that emissions are similar to other, better documented tar sand projects.
- In-situ steam injection and upgrading - which are assumed to produce steam by burning 0.5% coal with 99% control of particulates, but no sulfur dioxide controls.

3.1.3 Estimated Emissions from Proposed Facilities

3.1.3.1 Criteria Pollutants

Table 3.1-3 lists the estimated emission rates of particulates, sulfur oxides, oxides of nitrogen, carbon monoxide, and volatile organic compounds (VOC) for each of the proposed facilities for the cumulative proposed action. As shown, a production rate of 115,000 barrels per day (BPD) is estimated to result in 37,222 tons per year (TPY) of particulates, 6,883 TPY of SOx, 62,878 TPY of NOx, 8,282 TPY of CO and 3,602 TPY of VOC. Table 3.1-4 is a similar list for the cumulative partial conversion scenario. As shown, an estimated 20,839 TPY of particulates, 6,072 TPY of SOx, 63,843 TPY of NOX, 6,967 TPY of CO, and 3,109 TPY of VOC are estimated to result from the production of 90,000 BPD. Table 3.1-5 shows the emission inventory for the cumulative unitized development scenario. A production rate of 60,000 BPD is estimated to result in 18,018 TPY of particulates, 2,300 TPY of SOx, 26,188 TPY of NOx, 4,108 TPY of CO, and 4,618 TPY of VOC.

The major assumptions made by Aerocomp in developing the estimated emissions for each proposed project are listed in Table 3.1-6.

TABLE 3.1-3. EMISSION INVENTORY - CUMULATIVE PROPOSED ACTION

Company	Production (BPD)	Emission Rate (TPY)				
		TSP	SOx	NOx	CO	VOC
Amoco						
Plant	50000	1055	1580	12475	415	133
Mine		16978	837	13190	2617	995
Spent tar sand		2242	115	1873	322	97
Chevron						
Plant	10000	97	193	1352	97	580
Mine		2887	167	2638	523	170
Spent tar sand		971	23	375	64	19
Enercor						
Plant	20000	850	390	432	456	226
Mine		4073	335	5276	1047	342
Spent tar sand		555	46	749	129	39
Mono						
Plant -- extraction	30000	633	948	7485	249	80
-- upgrading		208	142	6783	435	259
Mine		4370	502	7914	1570	506
Spent tar sand		1242	69	1124	193	58
Sabine						
Plant -- stack	5000	105	1536	1212	162	81
-- fugitives		956	<1	<1	2	<1
TOTAL	115000	37222	6883	62878	8282	3602

Amoco -- hot water extraction; no upgrading. Reference 1,2,3,4, and 5.

Chevron -- hot water extraction and upgrading. Reference 1,2,4, and 5.

Enercor -- hot water extraction and upgrading. Reference 1,2,4,5, and 7.

Mono -- solvent extraction and upgrading. Reference 1,2,4, and 5.

Sabine -- in-situ steam injection; no upgrading. Reference 1,4,5,7, and 8.

TABLE 3.1-4. EMISSION INVENTORY - CUMULATIVE PARTIAL CONVERSION

		Emission Rate (TPY)				
Company	Production (BPD)	TSP	SOx	NOx	CO	VOC
Chevron	10000					
Plant		97	193	1352	97	580
Mine		2887	167	2638	523	170
Spent tar sand		971	23	375	64	19
Mono	75000					
Plant -- extraction		1583	2370	18713	623	200
-- upgrading		520	355	16958	1088	648
Mine		10777	1255	19785	3925	1266
Spent tar sand		2943	173	2810	483	145
Sabine	5000					
Plant -- stack		105	1536	1212	162	81
-- fugitives		956	<1	<1	2	<1
TOTAL	90000	20839	6072	63843	6967	3109

Chevron -- hot water extraction and upgrading. Reference 1,2,4, and 5.

Mono -- solvent extraction and upgrading. Reference 1,2,4, and 5.

Sabine -- in-situ steam injection; no upgrading. Reference 1,4,5,7, and 8.

TABLE 3.1-5. EMISSION INVENTORY - CUMULATIVE UNITIZED DEVELOPMENT

Company	Production (BPD)	Emission Rate (TPY)				
		TSP	SOx	NOx	CO	VOC
Chevron	60000					
Plant		582	1158	8112	582	3480
Mine		14916	1004	15828	3140	1022
Spent tar sand		2520	138	2248	386	116
TOTAL	60000	18018	2300	26188	4108	4618

Chevron -- hot water extraction and upgrading. Reference 1,2,4, and 5.

TABLE 3.1-6. FOOTNOTES FOR EMISSION INVENTORIES

[1] Tables 3.1-1 and 3.1-2.

[2] Mono Power Company Plan of Operation, revised April 19, 1983.

[3] Assume similar to Mono Power's solvent extraction plant. From Mono Power Company Plan of Operation, revised April 19, 1983.

[4] Tables of tar sand mined and disturbed land area provided by BLM, EIS Services, Denver Colorado.

[5] Response of the interested companies to a BLM questionnaire. BLM, EIS Services, Denver Colorado.

[6] Draft Uinta Basin EIS, Appendix R-B, Page R-B-5.

[7] Assume 443 tons of 0.5% S coal needed to produce 500 bbls of bitumen. Energy Requirements from Technology Assessment: Environmental Health, and Safety Impacts Associated with Oil Recovery from U.S. Tar-Sand Deposits, Lawrence Livermore National Laboratory, October 13, 1981.

[8] Assumed a ratio based on production for production well emissions presented by BLM Tar Sand Triangle Phase III emission inventory. Assumes 99% VOC controls.

3.1.3.2 Non-Criteria Pollutant Emissions

Emissions of other pollutants that may be characteristic of tar sand or oil shale processing, such as trace elements, are also of potential concern. Such pollutants as arsenic, beryllium, cadmium, chromium, mercury, nickel, lead, selenium, vanadium, and polycyclic aromatic hydrocarbons (PAH), among others, could be expected in one or more of the proposed tar sand mining, extraction, and upgrading processes and could have an impact on the environment.

Due to the relatively early stages of development of tar sand and oil shale technologies, only limited data are available regarding the release of non-criteria pollutants. A recent study conducted for the Health and Environmental Risk Analysis Program of the Department of Energy (IWG, 1982) considered the health effect risks associated with a one-million barrel-per-day oil shale industry in Colorado and Utah.

The pollutants having threshold effects which were analyzed in the study included several trace elements: hydrogen sulfide, arsenic, beryllium, cadmium, chromium, fluoride, lead, mercury, nickel, selenium, and vanadium. Hydrogen sulfide, beryllium, fluoride, lead, mercury, selenium, and vanadium were found to have no population exposures greater than the chosen threshold for potential health effects.

Four of the trace elements have also been associated with increased cancer risks: arsenic, cadmium, chromium, and nickel. Cadmium is associated with prostate cancer while the others are related to respiratory cancers. Polycyclic aromatic hydrocarbons (PAHs) are a class of organics which includes several carcinogenic species. Benzo(a)pyrene (BaP) is often used as an indicator of the carcinogenicity of the class. The study recognized the uncertainties involved with the analysis and the necessary simplifying assumptions in the absence of an adequate data base. Research recommendations for reducing the uncertainties were made.

Another study (Daniels, Anspaugh, Ricker 1981) assessed the potential health and ecosystem effects from air pollutants resulting from conceptual commercial surface and in situ facilities producing 20,000 BPD. The study examined potential emissions of the criteria pollutants (SO_2, TSP, NOx, HC, CO) as well as hydrogen sulfide. The conclusions of the study were that public health and ecosystem effects could occur, but they would be localized and/or controllable. The study recognized the uncertainties of the data base for the analysis and included a recommendation for studies to determine complete chemical characterization of emissions and specific control technologies that would be effective in protecting air quality from pollutants emitted by commercial tar sand facilities.

Volatilization of potentially toxic and odorous gases during the tar sand excavation, construction of spent tar sand piles, and from open-air process water containment ponds has been identified as a potential source of significant impact. Process water containing high concentrations of organic and inorganic substances (which would be used to moisturize spent tar sand for dust control, cooling, and compaction) could be volatilized during spent tar sand spreading through mechanisms such as evaporation, photodecomposition, and microbial conversions. A related source of fugitive gaseous emissions is process waters stored in open-air equalization basins. These sources could release various gases including ammonia, hydrogen sulfide, hydrocarbons, methylated metals, and pyridines. Release of these materials could produce an odor problem, which would probably be localized. An adequate data base for quantifying these potential emissions is not presently available. The Department of Energy began a study in 1982 to address both of these potential issues.

3.1.4 Emissions Resulting from Secondary Growth

3.1.4.1 Baseline 1981

The 1981 baseline emissions inventory was compiled using UBAQ's county-wide emission inventory for 1981 (UBAQ, 1982). UBAQ attributed all the 1981 emissions of the primary pollutants (TSP, SOx, CO, HC, and NOx) to the following source categories:

- highway vehicles,
- off-road vehicles,
- other transportation,
- process industries,
- space heating,
- electric power generation,
- fugitive dust,
- dirt roads, and
- forest fires.

County-wide emission rates for Carbon and Emery are provided in Table 3.1-7. Also included in the table are emission estimates for the future scenarios.

TABLE 3.1-7. COUNTY-WIDE EMISSIONS

Scenario & County	Pollutant Emission Rate (TPY)				
	TSP	SOx	CO	VOC	NOx
Baseline 1981					
Carbon	23,223	4,723	13,649	1,667	5,334
Emery	26,059	14,265	13,933	1,629	28,957
No Federal Action - 2005					
Carbon	52,238	4,837	12,402	1,691	5,349
Emery	39,768	17,018	8,526	1,056	49,537
Proposed Action - 2005					
Carbon	107,748	11,816	25,119	5,860	69,960
Emery	43,546	17,022	9,214	1,102	49,607
Partial Conversion - 2005					
Carbon	86,896	10,981	22,719	5,227	70,719
Emery	46,434	17,026	9,741	1,136	49,662
Unitized Development - 2005					
Carbon	83,149	7,168	19,671	16,191	37,516
Emery	41,767	17,020	8,891	1,080	49,574

In order to perform baseline TSP modeling analyses, the county-wide particulate emission rates were allocated to subcounty areas (EPA, 1974). In this procedure, an overall grid system using 10 km by 10 km grids was developed. Allocation factors were then assigned to each grid for population, transportation, forested areas, and a combined population and dirt road allocation. The total county particulate emissions were then allocated to each grid based on the appropriate factor.

Table 3.1-8 shows the allocation assumptions used for each pollutant source category. Population data was furnished by the BLM and access to Utah's emission inventory file was provided by UBAQ.

TABLE 3.1-8 POLLUTANT SOURCE CATEGORY AND RELATED ALLOCATION SCHEME

Source Category	Allocation based on:
highway vehicles	traffic volume maps *
off-highway vehicles	population
other transportation	population
process industries	UBAQ's emission inventory file
space heating	population
electric power generation	UBAQ's emission inventory file
dirt roads	population and unpaved road length
forest fires	area of forested lands

* Source: Utah Department of Transportation, 1981.

3.1.4.2 No Federal Action

Population projections for the year 2005 were provided by the BLM. The emissions from source categories which were assumed to be a function of population in Table 3.1-8 were increased linearly according to the projected population increases. Other researchers have assumed that emissions increase less than the rate of population. However, there is no data to support either assumption. VMT (vehicle miles traveled) was also incremented linearly with population increase. Units 3 and 4 of the Hunter Power Plant are assumed to be online in the year 2005 and were added to the "electric power generation" source category for the appropriate county. Emissions from all other source categories were kept at the 1981 level. Table 3.1-7 shows the expected county emissions for the year 2005 without the development of the tar sand areas.

County-wide particulate emissions were allocated to subcounty 10 by 10 km grids as discussed previously.

3.1.4.3 Proposed Action, Partial Conversion and Unitized Development

The estimated county-wide emissions for the year 2005, assuming the three development alternatives, are provided in Table 3.1-7. The pollution emission rates reflect population growth related emissions plus direct pollutant emissions from tar sand development. Population related emissions were calculated based upon data furnished by BLM.

3.1.4.4 Emission Summary

Table 3.1-9 lists the total emissions for Carbon and Emery counties for 1981, no Federal Action - Year 2005, Proposed Action - Year 2005, Partial Conversion - Year 2005, and Unitized Development - Year 2005. As shown, the emissions of all pollutants are expected to increase dramatically, regardless of the selected alternative. It should be noted that the volume of material to be handled in the mining process alone is many times greater than in any surface coal mine.

TABLE 3.1-9 EMISSION SUMMARY

	Pollutant Emission Rate (TPY)				
Scenario	TSP	SOx	CO	HC	NOx
1981-Baseline	49,282	18,988	27,582	3,296	34,291
2005-No Action	92,006	21,855	20,928	2,747	54,886
2005-Proposed Action	151,294	28,838	34,333	6,962	119,567
2005-Partial Conversion	133,330	28,007	32,460	6,363	120,381
2005-Unitized Development	124,916	24,188	28,562	17,271	87,090

3.2 DISPERSION MODELING METHODOLOGY

Atmospheric dispersion models and visibility models were applied to assess the impacts resulting from the implementation of tar sand development at the Sunnyside STSA. Both short-term (1-hour, 3-hour, and 24-hour) and long-term (annual) average air pollution levels were calculated. The magnitude, spatial distribution and frequency of occurrence of ground level concentrations of various air pollutants were simulated. Visibility impacts from plume blight were also modeled.

In this section, the approach adopted for the analysis of site-specific and regional impacts is described. The rationale for model selection as well as a discussion of input data used in the models are also included.

3.2.1 Model Selection Criteria

Models used in the air quality and visibility analysis are summarized in the following table:

TABLE 3.2-1. MODELS USED FOR THE AIR QUALITY AND VISIBILITY ANALYSIS

Model	Application
VALLEY-BID	site-specific, short term analysis for SO_2, TSP, and CO
VALLEY-BID	long-term analysis for NO_2, SO_2, TSP,
MESOPUFF	regional, short-term analysis for SO_2, SO_4, and TSP
BU501	3-D description of wind field
RPM-II	short-term analysis for ozone
BU422	area emissions
BU424/BU426	visibility analysis

For the short-term calculation of SO_2 and TSP, VALLEY-BID (VALLEY with buoyancy-induced dispersion) was used. The short-term mode of the model is generally considered to estimate the upper limits of 24-hour average pollutant concentrations from isolated sources in rural areas with complex terrain. VALLEY-BID was selected in this analysis for the following reasons:

- it is recommended by EPA for short-term screening in complex terrain,
- it is relatively inexpensive to run,
- it has been validated by the EPA; the results of the model agree reasonably well with the second highest 24-hour average concentration over one year, and
- an extensive on-site meteorological data base is not required.

Cost considerations were an important factor in the selection of VALLEY given the large number of runs that were required (independent model executions for 3 pollutants, 2 averaging periods, 10 cases).

Other sequential models for complex terrain, such as COMPLEX I, utilize on-site hourly meteorological data. COMPLEX I assumes horizontal homogeneity and employs one wind direction to describe the flow during each hour. In reality, wind direction normally fluctuates during a given hour, especially in complex terrain. Thus, the assumption will locate the plume-centerline improperly relative to the underlying surface. Moreover, it is felt that measurements at one point in the valley configuration of the study area are not necessarily representative of trajectory of air motion in the entire area (Irwin and Turner 1982). For screening applications, VALLEY-BID performs as well as, if not better than, the more expensive COMPLEX I. Therefore, VALLEY-BID was selected for short-term analysis in this study.

The long-term mode of VALLEY-BID was also used in the long-term analysis because it is the least expensive long-term, complex terrain model. It is felt that the model is the best tool for presenting the preliminary impact analysis. A more refined model may be used later for individual permit applications; at that time, more information on tar sand processing and facility siting should be available. Like other long-term models, (e.g., ISCLT, CDM) VALLEY-BID uses a STAR summary to calculate annual averaged concentrations. In effect, VALLEY is a rural CDM

(Schulze, 1982). VALLEY is capable of assessing plume impaction in complex terrain. Both point and area sources can be considered. Area sources are handled with a simple virtual point source technique. Aerocomp has compared the output of VALLEY-BID with that of the slightly more refined long term model, CDM, for both point and area sources and found that these two models agree reasonably well (within 20% for point sources and within 50% for area sources).

For short-term regional analysis, the most appropriate model available was MESOPUFF. A variable-trajectory Gaussian puff model, MESOPUFF contains the specific features needed for the analysis. For example, the model:

- can simulate deformation of a continuous plume,
- accommodates multiple point sources,
- includes modules for plume rise, plume growth, and fumigation,
- can handle conversion of SO_2 to SO_4, and dry and wet deposition,
- is a Lagrangian model and therefore computer costs are modest,
- can handle complex terrain effects,
- has been evaluated by the North Dakota State Department of Health (NDSDH), and
- has been expanded by Aerocomp to handle various particle sizes and to simulate line and area sources.

This code was one of seven long range transport models evaluated by the North Dakota State Department of Health (NDSDH) in support of PSD permit applications. Objective evaluations were performed in 1981 and results were announced at a hearing in September, 1981. The updated version prepared by NDSDH was used in this study. In addition, further modifications were made to the model to handle multiple particle sizes and to simulate line and area sources which need to be considered when mining is involved. Complex terrain effects were handled implicitly in the wind field supplied to MESOPUFF. This wind field was generated by Aerocomp's diagnostic wind model, BU501.

Version II of the Reactive Plume Model (RPM-II) was used for short-term photochemical analysis. The model was deemed appropriate because:

- it can simulate complex photochemical reactions in rural areas,
- it can treat both point and area sources,
- it can handle multiple sources, and
- it simulates plume trajectory in a Lagrangian sense and so it is relatively inexpensive to run.

RPM-II can be used to analyze a variety of air pollution problems involving reactive pollutant species. It has been successfully used to evaluate the impacts of NOx and hydrocarbon emissions upon ozone levels in downwind urban and rural areas. Furthermore, it is capable of treating multiple sources simultaneously if all sources are along a single wind trajectory. With the incorporation of a carbon bond mechanism, RPM-II is more sophisticated than most of the commonly used photochemical models including EKMA. Additionally, RPM-II requires less computer time than comparable models because it calculates concentrations in a Lagrangian sense. For instance, with the same chemistry and simulation conditions, the computer cost of running RPM-II is about one-fifth the cost of running an Eulerian model such as SMOG. Therefore, RPM-II was selected for modeling the short-term, regional photochemical impact in this study.

To save computer time, TSP concentrations from area emissions were calculated using BU422, a regression model developed by Aerocomp. The model empirically determines the relationship between local particulate emissions and ambient concentrations by regression of gridded emission density and observed air quality. Ground-level concentrations from the area emissions were estimated from the empirical relationships. The correlation between emissions and ambient concentrations obtained from the regression analysis provided reasonable confidence in the estimations.

The models used to assess the visibility impacts were BU424 and BU426. BU424 was used for the level-1 visibility analysis; it includes algorithms recommended by the EPA workbook (Latimer, 1980). BU424 can handle multiple sources. Its outputs have been compared with the example calculations in the EPA workbook to very good agreement.

Significant visibility impact due to plume blight was found in the level-1 analysis. Therefore, activation of BU426 was required to carry out the level-2 analysis. BU426 is modified from the EPA recommended algorithm and was used to calculate reductions in contrast and visual range as well as atmospheric discoloration. This model was selected to assess the potential for visibility impacts due to TSP and NOx emissions. The modeling methodology used to access impacts on visibility is summarized in Figure 3.2-1.

MESOPUFF was also selected to assess the impact of acid deposition because of the lack of a regional, long-term guideline model. MESOPUFF can simulate regional transport and linear chemistry and is appropriate for calculating short-term acid deposition. The short-term values can then be converted to long-term values using wind frequency statistics. Dry and wet deposition was estimated using an equivalent deposition velocity which was a function of meteorological conditions. The dry deposition velocity was determined based on information on surface roughness length, vertical diffusivity, and deposition height (Sehmel, 1980). Wet deposition velocity is a function of scavenging efficiency, precipitation rate, and depth of the precipitation layer.

A model-use matrix summarizing the codes used in the assessment (both site-specific and regional) is given in Table 3.2-2. Technical descriptions of each model are given in the next section.

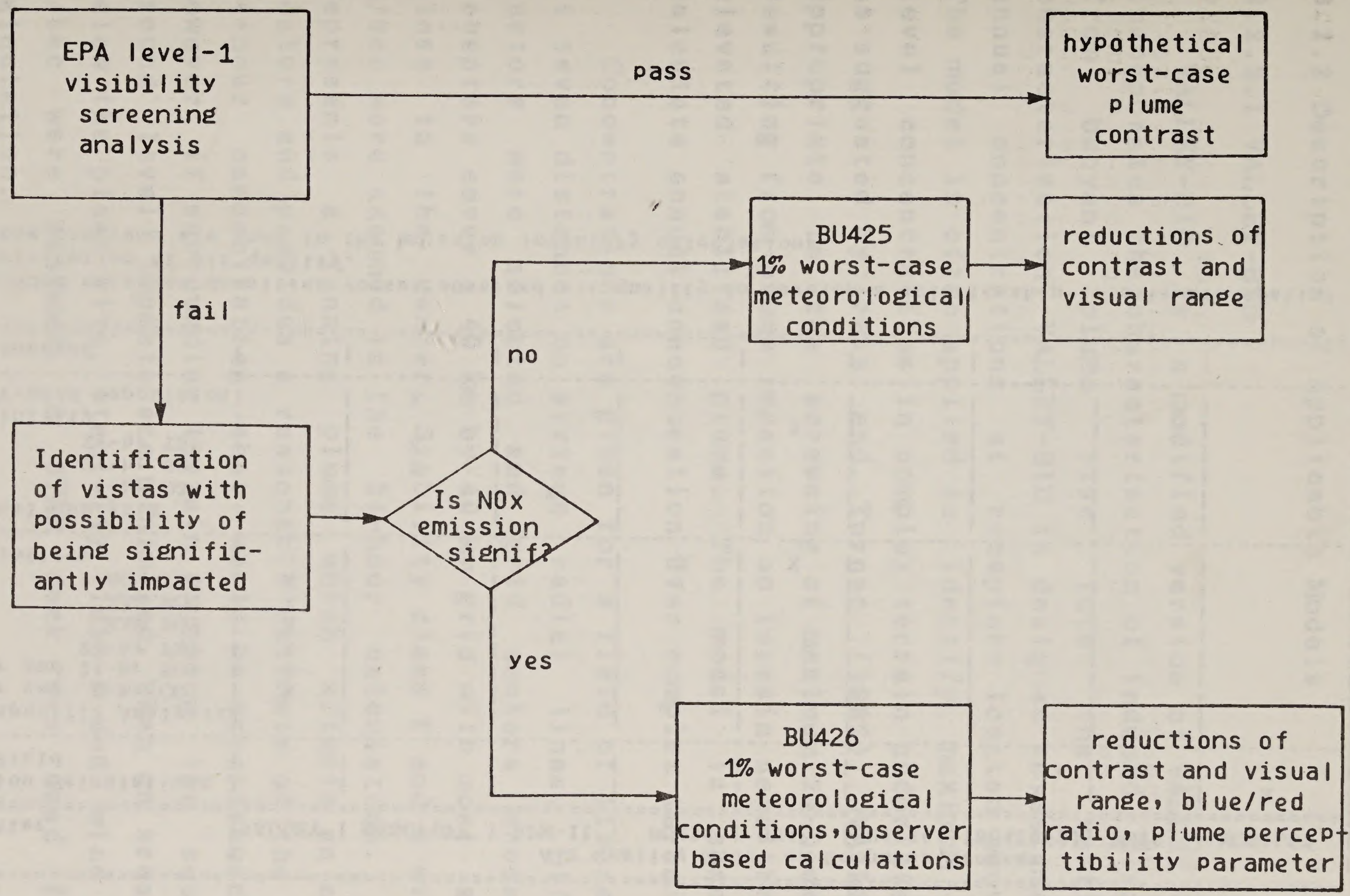
EPA level-1 visibility screening analysis
pass
hypothetical worst-case plume contrast
fail
Identification of vistas with possibility of being significantly impacted
Is NOx emission signif?
no
BU425 1% worst-case meteorological conditions
reductions of contrast and visual range
yes
BU426 1% worst-case meteorological conditions, observer based calculations
reductions of contrast and visual range, blue/red ratio, plume perceptibility parameter

Figure 3.2-1. Flow Diagram of Visibility Modeling

TABLE 3.2-2. MODEL USE MATRIX

	Air Quality Model or Computer Program								
Parameter	VALLEY	MESOPUFF	RPM-II	BU426	BU424	BU422(1)	BU420(2)	BU501	MOBILE2
Emission Calculations							X		X
Wind Field								X	
Site-specific Analysis									
1-hr and 8-hr CO	X								
3-hr and 24-hr SO2	X								
24-hr TSP	X								
AAM SO2	X								
AAM NO2	X								
AGM TSP	X								
Visibility				X	X				
Regional Analysis									
1-hr O3			X						
24-hr SO2		X							
24-hr TSP		X							
Visibility				X	X				
AQRV-acid deposition		X							
Area sources						X			

(1) Gridded emission densities versus observed air quality to develop a relationship to estimate spatial distribution of air quality.
(2) These programs are used in the emission inventory calculations.

3.2.2 Description of Applicable Models

3.2.2.1 VALLEY-BID

VALLEY-BID is a modified version of VALLEY (Burt, 1977) and incorporates the characterization of induced dispersion arising from buoyant plume rise into the vertical dispersion characterization. VALLEY-BID is designed to estimate 24-hour and annual concentrations at receptors located above plume height. The model is often applied to identify maximum 24-hour ground level concentrations in complex terrain under stable conditions. As suggested by Irwin and Turner (1982), VALLEY-BID is most appropriate in the screening of maximum 24-hour concentrations resulting from plume impaction on terrain near the height of an elevated stabilized plume. The model is also applicable to calculate annual concentration over complex terrain.

Concentrations are given for a field of 112 receptors located at seven distances on sixteen radial lines. Different scaling factors were selected and grid centers chosen such that the receptors cover a 40 km by 40 km grid with most sources located close to the center. Stability class F and a wind speed of 2.5 m/sec were assumed in the 24-hour calculation. This condition represents a fanning plume which affects an elevated terrain feature and provides a reasonable estimate of the second highest 24-hour concentration that would be experienced during a year. However, if surrounding terrain is below the source elevation, ground level impacts are minimized. When an area of concern was below the plant site, stability class D and wind speed of 2.5 m/sec were assumed. A STAR deck was used for the annual calculation.

The treatment of an elevated plume that has encountered terrain during stable conditions by VALLEY-BID is given in Figure 3.2-2. The model assumes that the plume level remains constant. Thus, as terrain rises, plume height decreases. The effective

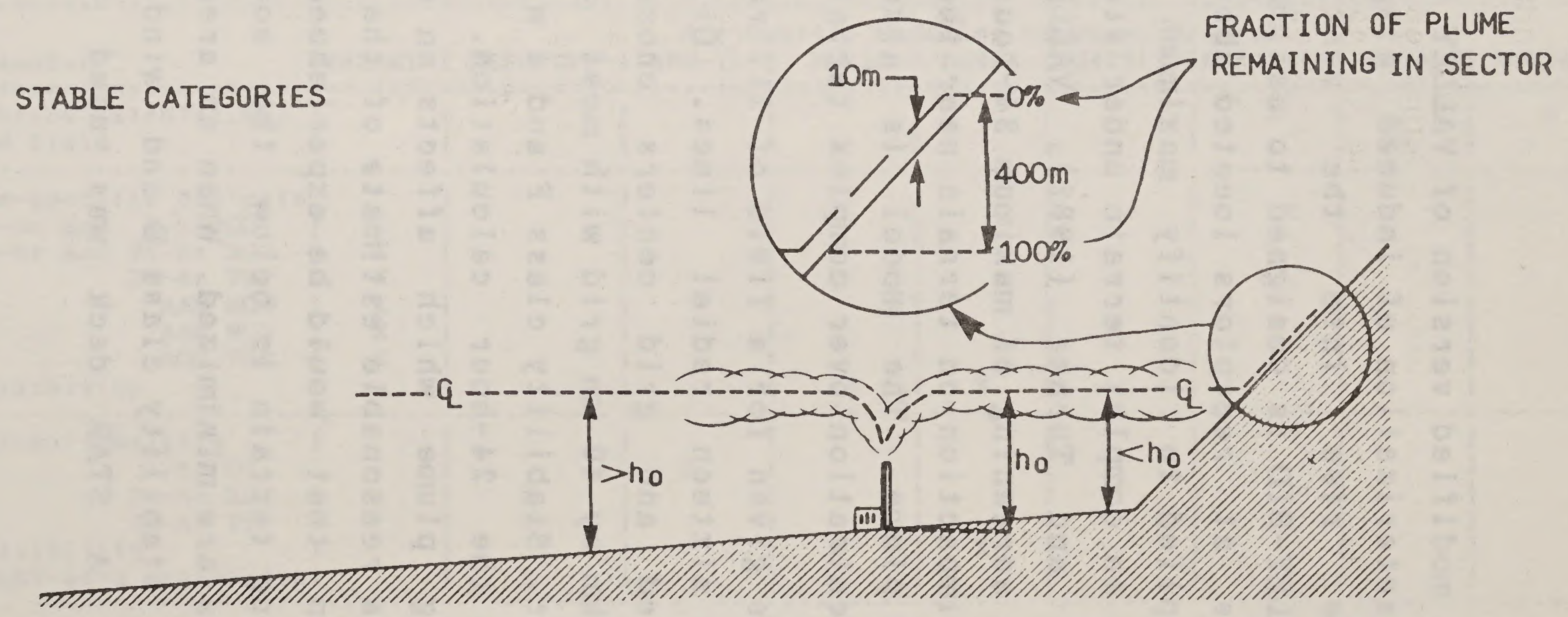

Figure 3.2-2. Depiction of Plume Height in Complex Terrain (After Burt, 1977)

plume height is calculated for each receptor by subtracting ground level elevations from the plume level. In no case, however, is the effective plume height allowed to be less than ten meters. Briggs' plume rise and buoyancy induced dispersion algorithms were incorporated in the analysis. The Pasquill-Gifford-Turner (P-G-T) scheme is applied for simulating vertical dispersion; however, the plume is assumed to be 22.5 degrees wide in the horizontal. The model assumes that a given type of meteorology will persist for 6 out of 24 hours.

The output of VALLEY-BID consists of a print-plot of calculated concentrations. The print-plots of each source, the total from all sources and an elevation map were produced for the study region. Based on the selected scaling factor, print-plots were overlayed on a 1:250,000 scale map to locate the maxima at each area of interest for each scenario.

3.2.2.2 MESOPUFF

As mentioned in the previous section, MESOPUFF, a mesoscale puff model, was used to assess short-term regional impacts. With MESOPUFF, each puff is advected in a Lagrangian sense, that is, its time history is independent of preceding and succeeding puffs. The puff centers are determined from wind trajectories, and the puff volumes are determined from Gaussian diffusion parameters. The diffusion characteristics of an individual puff are proportional to its travel distance (or travel time). A continuous plume is modeled by subdivision into a sufficient number of discrete puffs of circular horizontal cross section. A mass balance equation is applied to solve for concentrations of various species independently in each puff. MESOPUFF requires the following data at each model grid point:

- horizontal wind components,
- mixing depth, and
- P-G-T stability class.

There are three grid systems in MESOPUFF, a meteorological grid, a computational grid, and a sampling grid. The meteorological data is provided by BU501 (a meteorological data preprocessor developed by Aerocomp) and is set up on the 10km by 10km meteorological grid. All input data reference the computational grid. For example, estimations of the length of transport of puff centers and in-puff dispersion calculations were based on the computational grid. The size and grid spacing of the computational grid was the same as that of the meteorological grid. The sampling grid, which is the grid for the plume sampling function, was designed to be a subset of the computational grid with grid spacing denser by an integer multiple.

3.2.2.3 BU501, Wind Model

The wind model used in this study is a modified version of WEST (Winds Extrapolated from Stability and Terrain), a California ARB algorithm used in the SMOG air qualtiy model (Allen, 1982). The code is terrain-consistent, i.e., winds are forced to flow around terrain obstacles during stable atmospheric conditions. During unstable conditions the flow has a greater tendency to go over rather than around terrain. BU501 is flexible enough to use any and all available data, and its accuracy improves with additional data.

Atmospheric stability data are interpolated using an inverse square weighting to produce a stability field over the computational domain. Wind observations are projected upwards from the point measured through the portion of the grid without any measurement. The projections are based on a power law extrapolation of the form

$$S = S_o (Z/Z_o)^p$$

for speeds S and S_o at vertical coordinates Z and Z_o, respectively, with p determined by linear interpolation from the table below.

Stability Category	p
A	0.15
B	0.17
C	0.20
D	0.26
E	0.39
F	0.48

The maximum wind speed allowed in BU501 is 20 m/sec and the initial height is assumed equal to half a unit of the vertical grid. After the wind speeds are projected upwards, the speeds and directions are resolved into two horizontal components at every wind data site. Next, the entire wind field is developed via an inverse square weighted interpolation of the vertical profiles for each horizontal plane. Terrain influences first occur by shifting the interpolated winds upward to clear the terrain. Thus, a divergent wind field is calculated. Before the winds are made divergence-free, wind fluxes in and out of the boundaries of the computational domain are adjusted such that the flux in equals the flux out. Since atmospheric stability has the effect of varying the relative response to terrain of horizontal and vertical motion, the relative transparencies of the horizontal and vertical cell faces are allowed to be varied. The assignment of transparency was developed on the basis of simulations of idealized problems and appears to be qualitatively correct. Its assignment is as follows:

Stability Category	Horizontal Transperancy	Vertical Transparency
A	1.0	1.6
B	1.0	1.4
C	1.0	1.2
D	1.0	1.0
E	200.0	0.8
F	500.0	0.6

As conditions become more stable the winds are constrained to flow around terrain. Unstable conditions favor flow over terrain. Terrain cells are assigned zero transparency.

The non-divergence of the wind field is imposed by readjusting the velocity and minimizing the divergence term of the fluid mass continuity equation.

3.2.2.4 RPM-II

RPM-II is designed to accommodate large, non-linear chemical reaction mechanisms. It is capable of evaluating the effects of point and area emissions of hydrocarbon and nitrogen oxides upon ozone levels in downwind areas. The emphasis of the model is on chemistry. The model calculates dispersion based on user suppplied dispersion rates or stability information. In the latter case, P-G-T dispersion curves are utilized.

RPM-II is a Lagrangian model that follows a parcel of air as it progresses through space and time. The parcel of air contains initial concentrations and emissions of hydrocarbons and NOx that react according to the photochemical mechanism. During transport along the trajectory, fresh emissions are allowed to entrain into the plume parcel which is divided into several crosswind cells. Pollutant concentrations are assumed to be vertically constant (complete vertical mixing). A Gaussian distribution is imposed across the horizontal array of cells upon emitted pollutant species concentrations. Horizontal dispersion is simulated by expansion of the cells as the plume moves downwind as shown in Figure 3.2-3. For an inert species emitted from the source, the rates of expansion of these cells are determined by horizontal dispersion such that there is no net mass flux across cell boundaries. For a reactive pollutant, the Fickian diffusion approach is adopted. Diffusion coefficients are determined by finite difference approximations.

Since photochemical reactions in rural areas are those involving methane, CO, and trace organics such as naturally emitted terpenes, a 17-species, 68-step carbon bond mechanism (Whitten et al., 1980) was adopted. The plume trajectory was chosen with the following criteria:

- it passes through the largest tar sand development area
- it passes over Class I areas and/or sensitive receptors, and
- it has a high frequency of occurrence.

Simulation times were from 7:00 am to 5:00 pm. This is expected to be the period with strongest solar radiation and therefore the most likely time for the production of photochemical oxidants. Meteorological conditions were selected to represent the worst-case event associated with a shallow mixed layer on a worst-case day in summer. Ambient concentrations of NO_2, NO, O_3, SO_2, and CO were obtained from the monitoring stations in the study area.

3.2.2.5 BU422, Area Emissions

An empirical model for estimating TSP ambient concentrations from emission density was developed for the study. Table 2.1-2 summarizes the TSP monitoring data in the region. TSP emission densities in the vicinity of monitoring sites was determined using the procedure outlined in section 3.1.2. A least squares fit of the data was performed obtaining a high correlation between local particulate emissions and ambient concentrations (Figure 3.2-4).

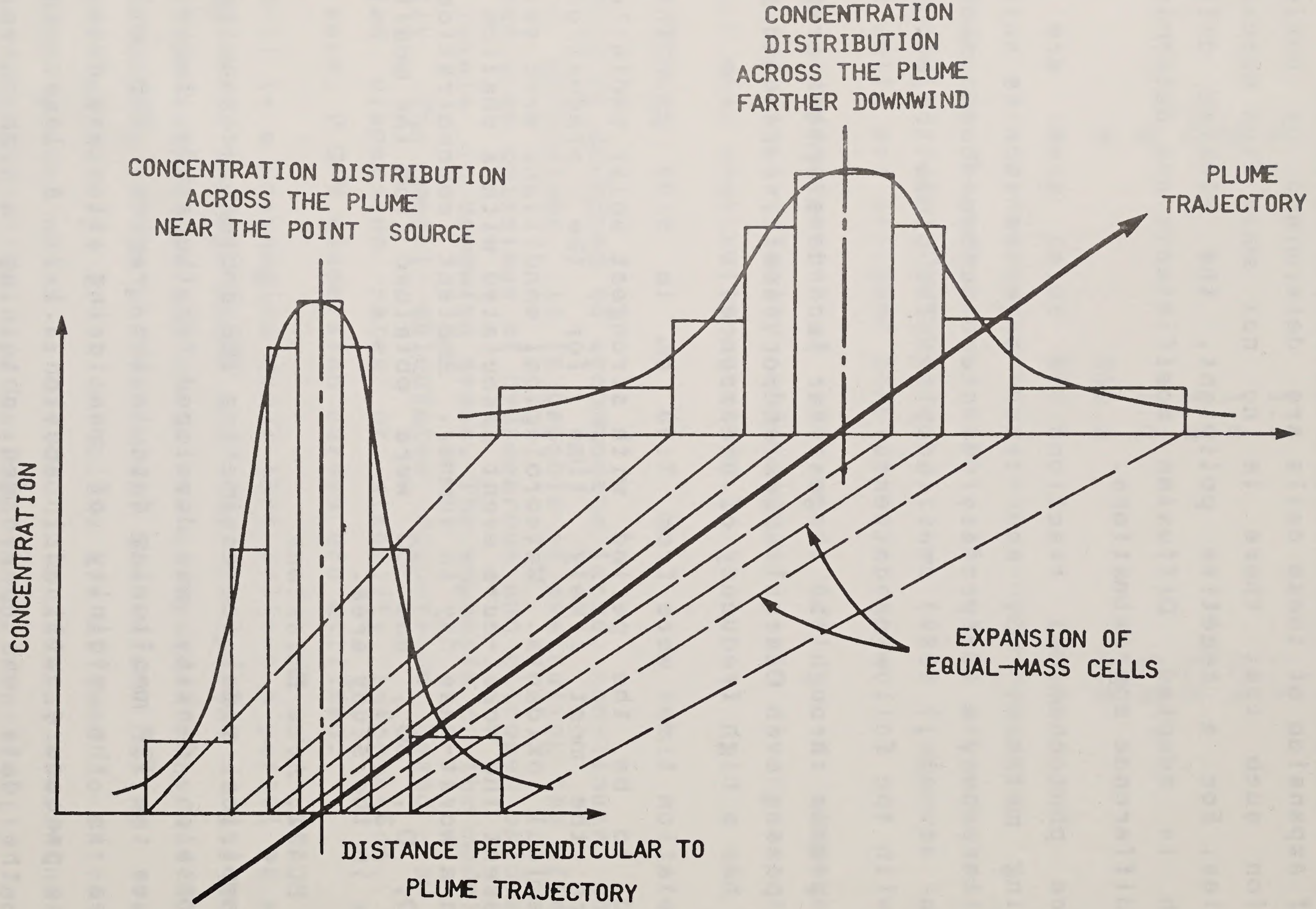
CONCENTRATION DISTRIBUTION ACROSS THE PLUME NEAR THE POINT SOURCE
CONCENTRATION DISTRIBUTION ACROSS THE PLUME FARTHER DOWNWIND
PLUME TRAJECTORY
CONCENTRATION
EXPANSION OF EQUAL-MASS CELLS
DISTANCE PERPENDICULAR TO PLUME TRAJECTORY

Figure 3.2-3. Schematic of Plume Expansion as a Function of Downwind Distance in RPM-II (After Stewart et al., 1980)

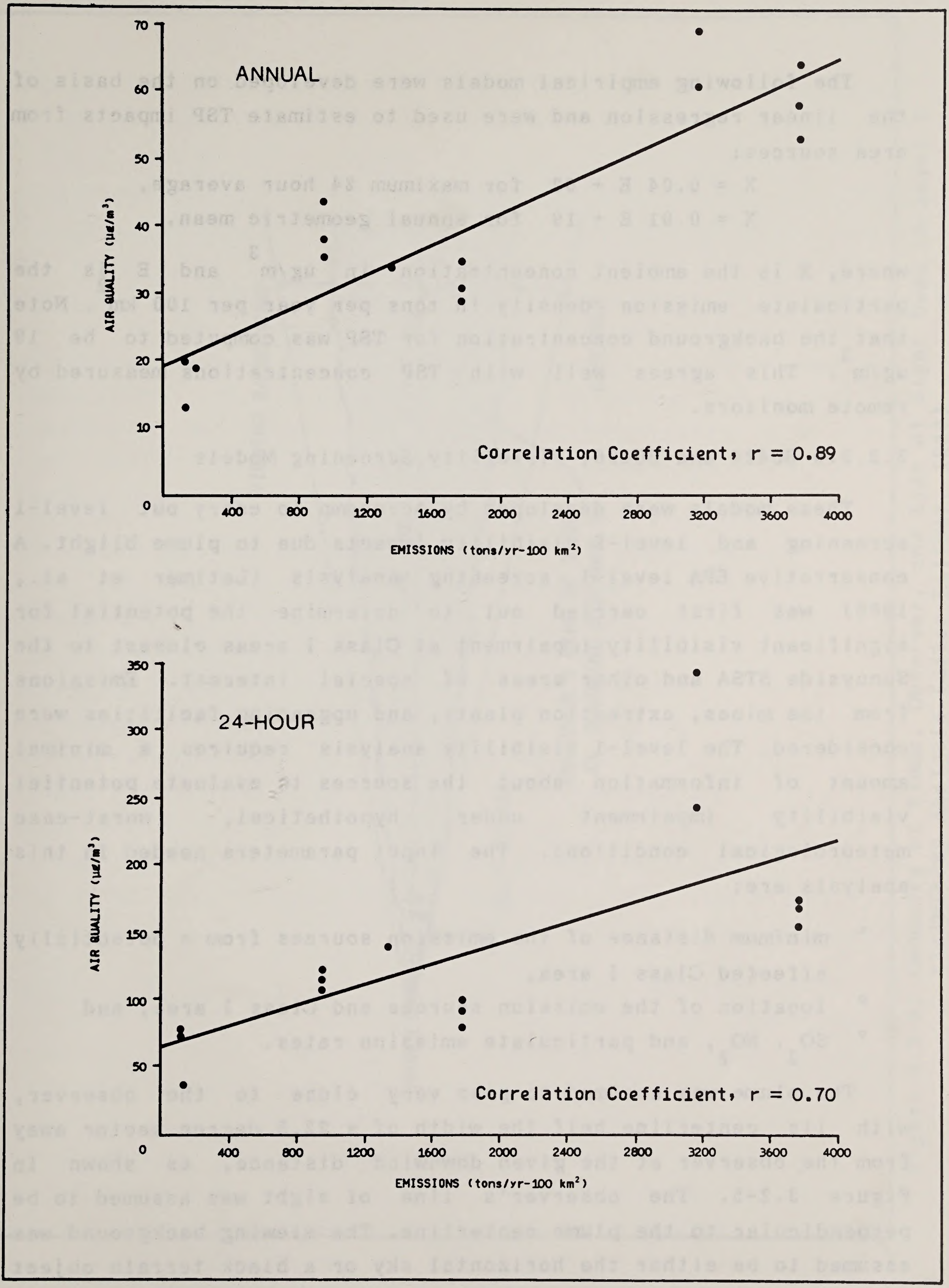

Figure 3.2-4. Relationship Between TSP Emissions and Ambient Air Quality

The following empirical models were developed on the basis of the linear regression and were used to estimate TSP impacts from area sources:

$X = 0.04\ E + 62$ for maximum 24 hour average,

$X = 0.01\ E + 19$ for annual geometric mean,

where, X is the ambient concentration in ug/m^3 and E is the particulate emission density in tons per year per 100 km^2. Note that the background concentration for TSP was computed to be 19 ug/m^3. This agrees well with TSP concentrations measured by remote monitors.

3.2.2.6 BU424 and BU426, Visibility Screening Models

These models were developed by Aerocomp to carry out level-1 screening and level-2 visibility impacts due to plume blight. A conservative EPA level-1 screening analysis (Latimer et al., 1980) was first carried out to determine the potential for significant visibility impairment at Class I areas closest to the Sunnyside STSA and other areas of special interest. Emissions from the mines, extraction plants, and upgrading facilities were considered. The level-1 visibility analysis requires a minimal amount of information about the sources to evaluate potential visibility impairment under hypothetical, worst-case meteorological conditions. The input parameters needed in this analysis are:

- minimum distance of the emission sources from a potentially affected Class I area,
- location of the emission sources and Class I area, and
- SO_2, NO_2, and particulate emission rates.

The plume was assumed to pass very close to the observer, with its centerline half the width of a 22.5 degree sector away from the observer at the given downwind distance, as shown in Figure 3.2-5. The observer's line of sight was assumed to be perpendicular to the plume centerline. The viewing background was assumed to be either the horizontal sky or a black terrain object

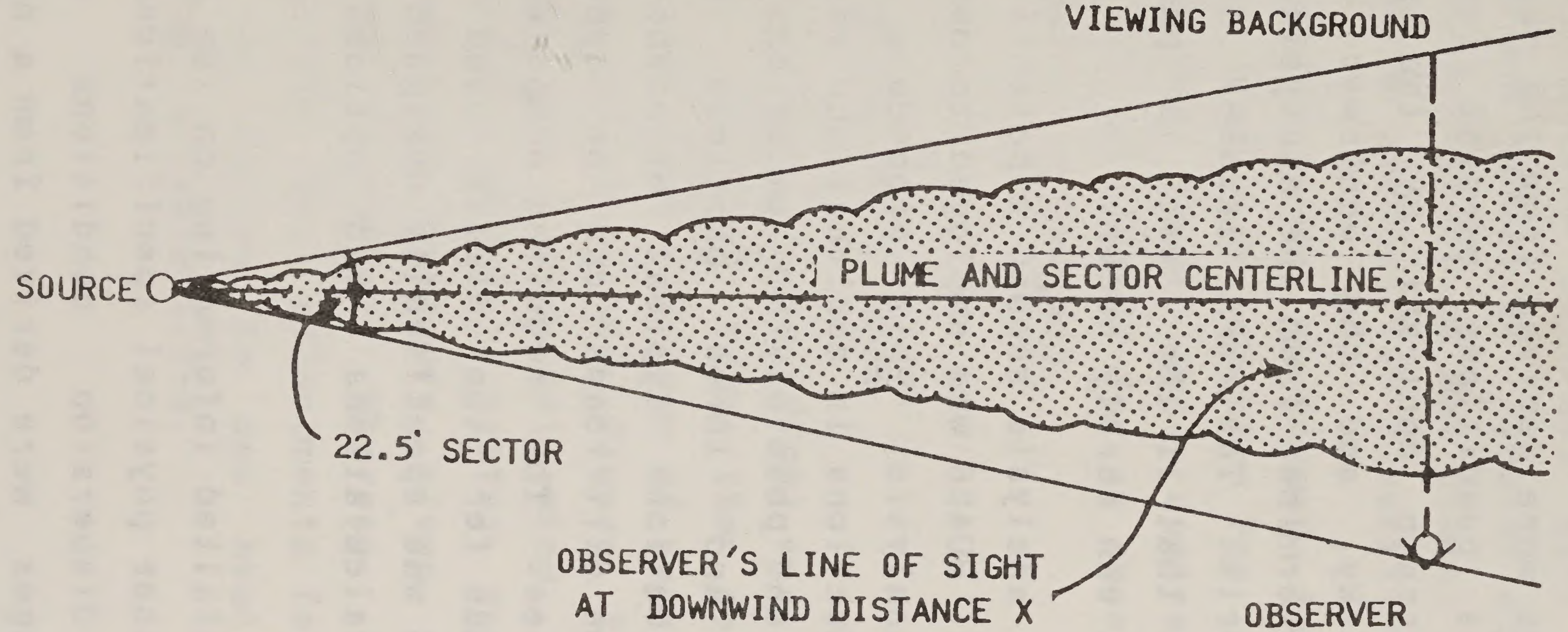

Figure 3.2-5. Geometry of Plume, Observer, and Line of Sight Used in Level I Visibility Analysis (After Latimer, 1980)

located on the opposite side of the plume at a distance equivalent to a full sector from the observer. Meteorological conditions were taken as stable with light winds. P-G-T F stability was used to characterize the vertical dispersion. Worst-case wind speeds were derived from the downwind distance by assuming that stable conditions persist for 12 hours. The reduction in sky/terrain contrast by the plume, the plume contrast against the sky, and the contrast reduction due to regional haze were determined from the analysis and were compared with contrast criteria. The EPA level-1 tests overestimate impacts to the extent that if the test is passed, significant visibility impairment can rarely occur.

As the level-1 analysis showed a potential for significant visibility impairment, BU426 was employed to carry out the more refined level-2 analysis. This procedure calculates plume discoloration and reductions in contrast and visual range due to particulates, NOx, and possibly SO_2 emissions. BU426 can handle up to 99 sources and three particle size categories. Particle-size distributions typical of airborne dust generated from transportation on dirt roads can be approximated by the three size categories. The required computer time for running BU426 is much less than for the widely used visibility model PLUVUE, because BU426 was specifically designed for this analysis and unnecessary calculations and options in PLUVUE were eliminated.

BU426 requires detailed information on the emission sources, meteorology, and other physical specifications of the site. One percent worst-case dispersion conditions were considered. Baseline visual ranges were derived from a national visibility map in the EPA Workbook (Latimer et al., 1980). Wind direction was assumed such that the plume traveled from the STSA to the observer. Lines of sight were assumed to be perpendicular to plume axis. This will maximize the plume contrast against sky and the blue-red ratio. Reductions of contrast and visual range against dark terrain will not be maximized. P-G-T dispersion coefficients were used and a horizontal line of sight was assumed.

Blue-red ratio, percentage reductions in visual range, and reduction in sky/terrain contrast were calculated using Mie scattering theory and radiative transfer algorithms. The sources are considered collectively as one plume. A virtual point source technique was used to account for diversity of the sources.

Model simulations were performed for various sources, scenarios, and lines of sight. For each simulation, the reductions in visual range and contrast and atmospheric discoloration were determined for an observer at a Class I area looking toward specified targets.

3.3.3 Model Inputs

3.3.3.1 Meteorological Input Data

A stability wind rose array (STAR) was developed for the long term air quality analysis from the sequential meteorology collected by Chevron near the town of Sunnyside from May 1982 to March 1983 (see Table 2.1-1 and Figure 2.1-2). Stability was determined using the horizontal wind direction fluctuation according to Mitchell and Timbre (1979). Table 3.2-3 was used to obtain P-G-T stability category given the lateral standard deviation of wind direction. Whereas, this relationship is adequate for daytime use, adjustments for nighttime conditions (one hour prior to sunset to one hour after sunrise) are necessary according to Table 3.2-4.

TABLE 3.2-3. RELATIONSHIP BETWEEN HORIZONTAL WIND DIRECTION STANDARD DEVIATION AND PASQUILL STABILITY CLASS (NRC, 1972)

Pasquill Category	Sigma Theta (degrees)
A	> 22.5
B	17.5 - 22.5
C	12.5 - 17.5
D	7.5 - 12.5
E	3.8 - 7.5
F	< 3.8

TABLE 3.2-4. NIGHTTIME P-G STABILITY CATEGORIES BASED ON HORIZONTAL WIND DIRECTION FLUCTUATIONS

Pasquill Category	10 m Wind Speed (m/s)	Resulting Pasquill Category
A	< 2.9	F
	2.9 - 3.6	E
	> 3.6	D
B	< 2.4	F
	2.4 - 3.0	E
	> 3.0	D
C	< 2.4	E
	> 2.4	D
D		D
E		E
F		F

December 14-16, 1979 was chosen for the short-term regional scale modeling performed with MESOPUFF. During that 48-hour period, an anticyclonic high pressure system was situated over east-central Utah causing fog, light winds, and weak atmospheric mixing. The surface isobar analysis, for December 15 and 16, 1979, is shown in Figure 3.2-6. Surface meteorological data at Cedar Mountain, Wellington, and U-a/U-b White River along with upper level winds at Grand Junction and Salt Lake City were used as input to Aerocomp's wind model, BU501 (see Section 3.2.2.3). A non-divergent wind field was then generated for use by MESOPUFF.

3.3.3.2 Emission Input Data

The annual and short-term emission rates and stack parameters used in the modeling analysis are provided in Table 3.2-5. Methodologies used to develop the emission inventory were discussed in section 3.1.2.

3.3.3.3 Input for Visibility Analysis

BU426 requires input of plume/observer/terrain geoemtry and 1% worst-case meteorological conditions. Viewing azimuth, viewing distance, and other source/observer/target geometry were determined by hand. Once a line of sight was identified, wind direction was chosen such that the wind blew from the sources perpendicularly to the sight path. A 1% worst-case dispersion condition (wind speed and stability class) associated with this wind direction was determined such that the sum of all frequencies of occurrence of dispersion conditions worse than this condition totaled 1 % (i.e., about four days per year). The input data for visibility analysis for each line of sight are given in Table 3.2-6.

3.3.3.4 Summary of Modeling Assumptions

MESOPUFF modeling assumptions are as follows:

- winds 150-300 m above the terrain were used to advect puffs,
- meteorological grid spacing - 10 km,
- computational grid spacing - 10 km,
- sampling grid spacing - 10 km,
- SO_2 to SO_4 conversion rate - 2.78×10^{-6} sec^{-1},

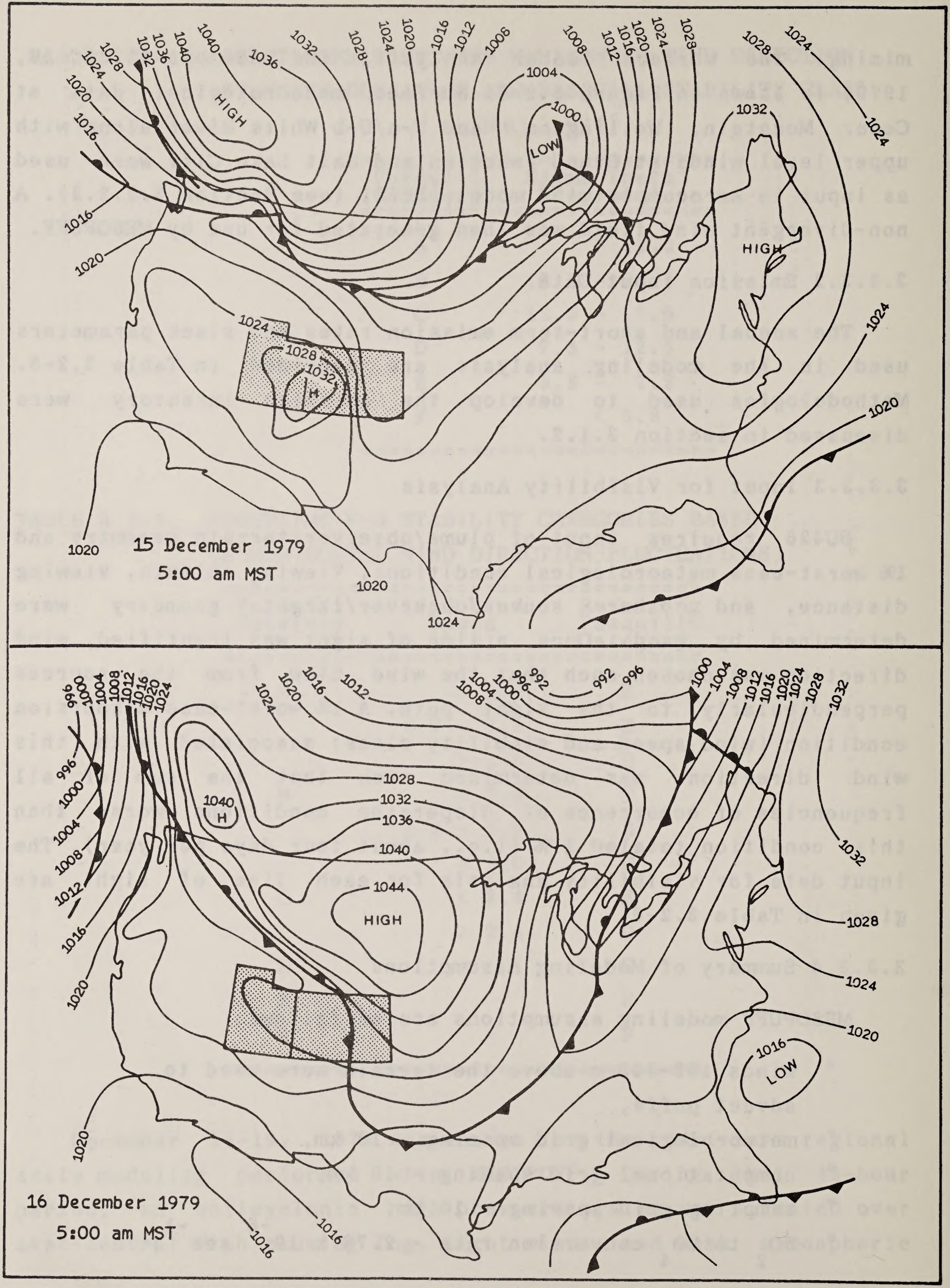

Figure 3.2-6. Surface Isobar Analysis for December 15 and 16, 1979

TABLE 3.2-5. EMISSION INPUT FOR VALLEY MODELING ANALYSIS.

Scenario Source	Annual Emission Rates (g/s)			Short-term Emission Rates (g/s)			Stack Parameters			
	TSP	SOx	NOx	TSP	SOx	NOx	Height (m)	Diameter (m)	Velocity (m/s)	Temperature (°K)
Proposed Action - Collective										
Amoco										
plant	30.4	45.5	359.9	34.6	51.9	--	66	8.0	12.0	393
mine	*	24.1	379.9	*	25.1	--	3	2000	--	--
spent tar sand	*	3.3	53.9	*	3.8	--	3	2000	--	--
Enercor										
plant	24.5	11.2	12.4	27.0	12.5	--	33	5.0	12.0	393
mine	*	9.7	152.0	*	10.7	--	3	2000	--	--
spent tar sand	*	1.3	21.6	*	1.5	--	3	2000	--	--
Mono										
plant -- extraction	18.2	27.3	215.6	18.2	27.3	--	33	5.0	12.0	393
-- upgrading	6.0	4.1	195.4	6.0	4.1	--	55	6.0	12.0	393
mine	*	14.5	227.9	*	14.5	--	3	2000	--	--
spent tar sand	*	2.0	32.4	*	2.0	--	3	2000	--	--
Sabine										
stacks	3.0	44.2	34.9	3.7	54.0	--	33	2.0	10.0	473
Proposed Action - Cumulative										
Amoco										
plant	30.4	45.5	359.9	34.6	51.9	--	66	8.0	12.0	393
mine	*	24.1	379.9	*	25.1	--	3	2000	--	--
spent tar sand	*	3.3	53.9	*	3.8	--	3	2000	--	--
Chevron										
plant	2.8	5.6	38.9	2.8	5.7	--	33	4.0	10.0	533
mine	*	4.8	76.0	*	5.8	--	3	2000	--	--
spent tar sand	*	0.7	10.9	*	0.7	--	3	2000	--	--
Enercor										
plant	24.5	11.2	12.4	27.0	12.5	--	33	5.0	12.0	393
mine	*	9.7	152.0	*	10.7	--	3	2000	--	--
spent tar sand	*	1.3	21.6	*	1.5	--	3	2000	--	--
Mono										
plant -- extraction	18.2	27.3	215.6	18.2	27.3	--	33	5.0	12.0	393
-- upgrading	6.0	4.1	195.4	6.0	4.1	--	55	6.0	12.0	393
mine	*	14.5	227.9	*	14.5	--	3	2000	--	--
spent tar sand	*	2.0	32.4	*	2.0	--	3	2000	--	--
Sabine										
stacks	3.0	44.2	34.9	3.7	54.0	--	33	2.0	10.0	473

* Fugitive TSP modeled by BU422.

TABLE 3.2-5. (Continued)

Scenario Source	Annual Emission Rates (g/s)			Short-term Emission Rates (g/s)			Stack Parameters			
	TSP	SOx	NOx	TSP	SOx	NOx	Height (m)	Diameter (m)	Velocity (m/s)	Temperature (°K)
Partial Conversion - Collective										
Mono (75,000 BPD)										
plant -- extraction	44.3	66.4	524.0	44.3	66.4	--	66	8.0	12.0	393
-- upgrading	14.6	9.9	474.8	14.6	9.9	--	66	8.0	12.0	393
mine	*	35.1	554.0	*	35.1	--	3	2000	--	--
spent tar sand	*	4.8	78.7	*	4.8	--	3	2000	--	--
Sabine										
stacks	3.0	44.2	34.9	3.7	54.0	--	33	2.0	10.0	473
Partial Conversion - Cumulative										
Chevron										
plant	2.8	5.6	38.9	2.8	5.7	--	33	4.0	10.0	533
mine	*	4.8	76.0	*	5.8	--	3	2000	--	--
spent tar sand	*	0.7	10.9	*	0.7	--	3	2000	--	--
Mono (75,000 BPD)										
plant -- extraction	44.3	66.4	524.0	44.3	66.4	--	66	8.0	12.0	393
-- upgrading	14.6	9.9	474.8	14.6	9.9	--	66	8.0	12.0	393
mine	*	35.1	554.0	*	35.1	--	3	2000	--	--
spent tar sand	*	4.8	78.7	*	4.8	--	3	2000	--	--
Sabine										
stacks	3.0	44.2	34.9	3.7	54.0	--	33	2.0	10.0	473
Unitized Development - Collective										
Chevron (50,000 BPD)										
plant	13.7	27.0	189.3	13.9	27.4	--	66	8.0	10.0	533
mine	*	23.4	369.2	*	28.6	--	3	2000	--	--
spent tar sand	*	3.2	52.4	*	3.3	--	3	2000	--	--
Unitized Development - Cumulative										
Chevron (60,000 BPD)										
plant	16.4	32.6	228.2	16.6	33.0	--	66	9.0	10.0	533
mine	*	28.3	445.2	*	34.5	--	3	2000	--	--
spent tar sand	*	3.9	63.2	*	3.9	--	3	2000	--	--

* Fugitive TSP modeled by BU422.

TABLE 3.2-6. INPUT DATA FOR VISIBILITY ANALYSIS FOR EACH SIGHT PATH

Observer Point	Observer-Source Distance (km)	Observer-Terrain Distance (km)	Wind Direction	1% Stability Class	1% Wind Speed (m/s)	Viewing Azimuth	Scattering Angle
Capitol Reef National Park	155	50	NNE	F	3	300°	150°
Canyonlands National Park	145	50	NNW	F	3	250°	160°
Arches National Park	122	50	NW	F	3	230°	140°
Dinosaur National Monument	136	50	SW	D	3	120°	30°
Uintah & Ouray Indian Res - South	40	50	WSW	D	3	150°	60°
Uintah & Ouray Indian Res - North	58	50	SSE	E	3	70°	20°

Other Input Parameters

Size Distribution :

< 2.5 um	0.1
2.5 um - 15 um	0.3
> 15 um	0.6

Background Visual Range : 170 km

Ozone Concentration : 0.035 ppm

- SO_2 deposition velocity - 0.01 m/sec,
- SO_4 deposition velocity - 0.001 m/sec,
- area source width - 2 km,
- area source release height - 3 m, and
- mixing height varies with time and ranges from 300 m in the morning to 1100 m in the afternoon.

BU501 modeling assumptions are as follows:

- grid cell dimensions - 5 km by 5 km by 150 m,
- wind field dimensions,
  - x-axis - 255 km
  - y-axis - 370 km
  - z-axis - 2700 m
- winds 150-300 m above the terrain used in MESOPUFF analysis.

VALLEY-BID modeling assumptions are as follows:

- ambient pressure - 850 mb,
- ambient temperature - 284°K,
- grid dimension - 35 km radius,
- mean maximum afternoon mixing height 2500 m,
- pollutant half life - 72 hours,
- area source width - 2 km,
- area source release height - 3 m, and
- distance between adjacent downwind receptors - 5 km.

RPM-II modeling assumptions are as follows:

- number of cells across the plume - 6,
- simulation time - 10 hours,
- simulation distance - 216 km,
- error bound used in solving ordinary differential equation - 0.005
- tolerance limit for steady-state approximation - 0.005,
- chemical kinetics - carbon bond mechanism,
- wind speed - 6 m/sec,
- stability - P-G class B,

- mixing height - 250 m at 7 am
  - 1000 m after 12 pm
- photolysis rate - 0.15 at 7 am
  - 0.40 at 10 am
  - 0.48 at 12 pm
  - 0.35 at 3 pm
  - 0.10 at 5 pm

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GLOSSARY

Some of the following definitions are abstracted directly from Glossary of Meteorology, Ralph E. Huschke, editor. American Meteorological Society, Boston. 1959. 638p.

ADVECTION - The process of transport of an atmospheric property solely by the mass motion (velocity field) of the atmosphere. The description of predominantly horizontal large scale motions of the atmosphere.

AIR BASIN - An area created by topographic boundaries which serves to contain air pollutants emitted into the area by pollution sources and to restrict air exchange with other air basins.

AIR MASS - A widespread body of air that is approximately homogeneous in its horizontal and vertical extent, particularly with reference to temperature and moisture distribution.

AIR POLLUTION - The presence of substances in the air in sufficient amount to interfere significantly with the comfort, health, and welfare of persons and their property.

AIR POLLUTION CONTROL AGENCY - A local agency, usually on the county level, charged with controlling pollutants discharged into the atmosphere.

AIR QUALITY CRITERIA - The varying amounts of pollution and lengths of exposure at which specified adverse affects to health and welfare take place.

AIR QUALITY MODEL - A mathematical representation of the behavior of air pollutants or their effects on air quality related values.

AIR QUALITY RELATED VALUE (AQRV) - A feature or property of an area--e.g., visibility--that is affected in some way by air pollution.

ALGORITHM - A procedure for solving a problem (as in mathematics) that frequently involves repetition of an operation.

AMBIENT AIR QUALITY - Concentration levels in ambient air for a specified pollutant and a specified averaging time period within a given area.

AMBIENT AIR QUALITY STANDARD - A level of ambient air quality established by federal or state agencies which is to be achieved and maintained; primary standards are those judged necessary, with an adequate margin of safety, to protect the public health; secondary standards are those judged necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Ambient standards are given in micrograms per cubic meter.

ANTICYCLONE - A large-scale atmospheric circulation in which the winds rotate clockwise in the Northern Hemisphere and counter-clockwise in the Southern Hemisphere.

ATMOSPHERE - Gaseous mass surrounding the earth composed primarily of oxygen and nitrogen.

ATMOSPHERIC STABILITY - State of the atmosphere as related to vertical motions. In stable conditions the temperature increases with height and vertical motions are inhibited. Under these conditions, pollutants emitted at the ground tend to accumulate, while effluents from elevated sources normally remain aloft for larger distances. In unstable conditions the temperature decreases rapidly with height and vertical motion is enhanced. Low-level emissions are dispersed rapidly upward while high-level emissions are brought rapidly to the ground. Under these conditions, elevated sources frequently make their maximum contribution to short-term ambient pollutant concentrations. Between the stable and unstable conditions is the situation in which the vertical temperature profile decreases adiabatically. This condition is called neutral stability with near-neutral conditions quite frequent in most locations. For sources with tall stacks the high wind speed neutral condition suppresses plume rise, and high ground-level concentrations are often observed. For ground-level emissions, the concentrations for near-neutral conditions are normally between the stable and unstable cases.

ATTAINMENT AREA - A region where ambient concentrations of criteria pollutants are lower than the levels specified as minimal standards for protecting public health and welfare, i.e., the NAAQS.

BAGHOUSE - An air pollution abatement device that traps particulates (dust) by forcing gas streams through large filter bags, usually made of glass fibers.

BEST AVAILABLE CONTROL TECHNOLOGY (BACT) - An emission limitation applied to a new or modified major stationary source in an attainment area, determined on a case-by-case basis taking into account environmental consequences, energy considerations, and economic impacts.

BEST AVAILABLE RETROFIT TECHNOLOGY (BART) - An emission limitation applied to an existing major stationary source that may reasonably be anticipated to cause or to contribute to impairment of visibility in a mandatory Class I area.

CALM - A period when the air is motionless. In the United States, the wind is reported as calm if it has a speed of less than one mile per hour (or one knot).

CARBON MONOXIDE (CO) - A colorless, odorless, toxic gas produced by the incomplete combustion of carbon-containing substances. One of the major air pollutants, it is emitted in large quantities by exhaust of gasoline-powered vehicles.

CATALYTIC CONVERTER - An air pollution abatement device that removes organic contaminants by oxidizing them into carbon dioxide and water through chemical reaction.

CHANNELING - An aerodynamic phenomena of wind flow in a street, canyon, river valley, or hilly terrain that causes a persistent flow of wind and pollutants parallel to the street, river, or hill.

CLASS I, II, AND III AREAS - Regions in attainment areas where maintenance of existing good air quality is of high priority. In Class I areas, maintaining air quality is regarded as having the highest priority with respect to other values; in Class III areas, air quality has lower priority than it does in the other areas. Initially, all attainment areas except mandatory Class I areas were designated Class II.

CLIMATOLOGY - Branch of meteorology dedicated to the study of long periods of observed weather at a specified area. The study of the long-term manifestations of weather.

CONCENTRATION - A measure of the average density of a pollutant usually specified in terms of pollutant mass per unit volume of air (e.g., micrograms per cubic meter), or in terms of relative volume of pollutant per unit volume of air (e.g., parts per million).

CONVECTION - Atmospheric motions resulting in upward vertical transport and mixing of atmospheric properties.

CRITERIA POLLUTANT - A pollutant for which a national ambient air quality standard (NAAQS) has been established, i.e., sulfur dioxide, total suspended particulate mass, hydrocarbons, carbon monoxide, ozone, lead, and nitrogen dioxide.

CYCLONE - An air pollution abatement device that removes heavy particles through centrifugal force.

CYCLONE - A large-scale atmospheric circulation having a sense of rotation about the local vertical, counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

DIFFUSION - A process of spontaneous intermixing of different substances tending to produce uniformity in conservative properties.

DIGITIZED DATA - Data which is recorded in a computer acceptable format (as opposed to analog or strip chart data).

DISPERSION - The phenomenon by which a given quantity of pollutant is distributed over a given area.

DISPERSION MODELING - The mathematical representation or simulation of transport processes that occur in the atmosphere.

DIURNAL - Time period pertaining to events that occur at the same time of the day, usually in a lengthy record.

DOWNWIND - The direction toward which the wind is blowing; direction of flow vector.

DRAINAGE FLOW - Typical of mountain regions and caused by the gravitation of cold air off high ground.

DRAINAGE WIND - A wind directed down the slope of an incline and caused by greater air density near the slope than at the same level some distance horizontally from the slope.

DUST - Solid particles capable of temporary suspension in the air or other gases; one of several types of particulate matter.

EDDY - A portion of fluid within the fluid mass that has a certain integrity and life history of its own.

EFFECTIVE STACK HEIGHT - The physical stack height plus plume rise, i.e., the point above the ground at which the gaseous effluent becomes essentially level.

EFFLUENT (EMISSION) - Any pollutants discharged to the atmosphere.

ELECTROSTATIC PRECIPITATOR - An air pollution abatement device that removes particulate matter by forcing the gas stream through an electrical field which charges the particles so they can be collected on an electrode.

ELEVATED INVERSION - An inversion layer above the immediate surface. Such an inversion inhibits the dispersion of buoyant pollutants, such as those given off by power facilities and refineries.

EMISSION - Effluent discharge into the atmosphere, usually specified in terms of mass per unit time.

EMISSION INVENTORY - A list of air pollutants emitted into a community's atmosphere, in amounts (commonly tons) per day, by type of source.

EMISSION INVENTORY - Dataset containing emission source information usually for use in the application of an air quality simulation model.

EMISSION STANDARD - Rule or measurement established to regulate or control the amount of a given pollutant which may be discharged to the outdoor atmosphere from its source.

EMPIRICAL - An approach based upon observations and experimentation.

ELEVATED INVERSION - An inversion characterized by its base being displaced above the earth's surface. Elevated inversions can be, for example, initiated by subsidence of air from upper atmospheric levels or are the transitional zones between dissimilar air masses.

ENVIRONMENTAL PROTECTION AGENCY (EPA) - Group charged with enforcement of Federal regulations designed to control air pollution. Good source for information, literature, films, etc. Address is E. P. A., Office of Public Affairs, Parklawn

Building, 5600 Fishers Lane, Rockville, MD 20852.

FEDERAL LAND MANAGER - The Secretary of the department of the federal government under whose jurisdiction a piece of federal land is managed.

FLUE GAS - A mixture of gases resulting from combustion and other reactions in a furnace and then channeled through a chimney or stack into the outdoor air.

FLY ASH - Gas-borne particles of matter resulting from the combustion of fuels and other materials.

FRONT - In meteorology, generally, the interface or transition zone between two air masses of different density.

FUGITIVE DUST - Solid airborne particles emitted from any source other than a stack.

FUGITIVE SOURCE - A source emitting pollutants other than from a stack.

FUMIGATION - The rapid mixing downward to the ground of material previously emitted into a stable layer. A common occurrence when the nocturnal temperature inversion is rapidly dissipated by solar heating of the surface. This condition often occurs in sea breeze circulations during late morning or early afternoon.

GAUSSIAN PLUME EQUATION - The diffusion equation which assumes the plume has a normal distribution both in the horizontal and vertical.

HI-VOLUME SAMPLER - A device used to collect a sample of particulate matter on a filter; often called a Hi-Vol.

HYDROCARBON - Any of a vast family of compounds containing carbon and hydrogen in various combinations; found especially in fossil fuels. Some of the hydrocarbons are major air pollutants: they may be active participants in the photochemical process or affect health.

HYDROGEN SULFIDE - A gas characterized by "rotten egg" smell, found in the vicinity of oil refineries, chemical plants, and sewage treatment plants.

INCREMENTS - Maximum allowable increases over baseline concentrations of pollutants covered by the PSD provisions in Class I, II, and III areas.

INSOLATION - Incoming solar radiation received at the earth's surface.

INVERSION - A departure from the usual decrease in temperature with altitude. An inversion layer refers to the layer through which an increase in potential temperature with height occurs. In a temperature inversion, temperature increases with altitude. A temperature inversion is stable, allowing little turbulent exchange to occur.

INVERSION BASE - The level in which the temperature ceases to decrease with altitude.

INVERSION LAYER - That layer of air which departs from the usual decreases in temperature with increasing altitude.

ISOPLETH - A line or contour drawn on a map denoting points having equal value of a quantity; e.g., similar temperature (isotherm), pressure (isobar), or pollutant concentrations.

LINE SOURCE - A source of pollutants occurring at a reasonably continuous rate along a fixed line (e.g., highway).

MAJOR SOURCE - Any source in an attainment area that emits at least 250 tons of any pollutant regulated under the Clean Air Act or any source from among 28 categories of sources that emits at least 100 tons per year of any regulated pollutant.

MANDATORY CLASS I AREA - An international park, a national wilderness area or national memorial park larger than 5,000 acres, or a national park larger than 6,000 acres. States may not reclassify mandatory Class I areas.

MAXIMUM MIXING LAYER - The maximum potential depth of air available for dilution of pollutant emissions. Maximum mixing depth is a function of solar angle and type of terrain at a particular location.

MECHANICAL TURBULENCE - Turbulence resulting from the interaction of the wind flow with topographic features.

MICRO - A prefix meaning 1/1,000,000.

MICRON - A unit of length equal to one thousandth of a millimeter or about 1/25,000 of an inch.

MILLI - a prefix meaning 1/1,000.

MIXING HEIGHT/DEPTH - Height of the layer of air where well-mixed conditions exist, usually the height of the first significant inversion above the surface.

MIXING LAYER - The volume of air available for the dilution of pollutant emissions.

NEUTRAL ATMOSPHERIC STABILITY - Neutral stratification of the atmosphere, i.e., the lapse rate is equal to the dry-adiabatic lapse rate, therefore, a parcel of air displaced vertically will experience no buoyant acceleration.

NITROGEN OXIDES - Gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and high presure; considered a major air pollutant.

NOCTURNAL INVERSION - Surface-based inversion induced by radiational cooling.

NONATTAINMENT AREA - A region where ambient concentrations of criteria pollutants are higher than the levels specified as minimal standards for protecting public health and welfare, i.e., the NAAQS.

OPACITY - Ratio of the light attenuated by particulate matter to the incident light. Degree of obscuration of light. For example, a window is "0" in opacity, a wall is 100% opaque. The Ringelmann system of evaluating smoke density is based on opacity.

ORGANIC COMPOUNDS - Large group of chemical compounds that contain carbon. All living organisms are made up of organic compounds. Some types of organic gases, including olefins, substituted aromatics and aldehydes, are highly reactive - that is, participate in photochemical reactions in the atmosphere to form oxidant.

OXIDANT - Substance in the air (e.g., nitrogen dioxide, ozone) which make available oxygen or oxygenated compounds for chemical reaction. Oxidants are formed, for example, from the reaction of certain reactive hydrocarbons and nitrogen dioxide, under the influence of sunlight.

OZONE - A pungent, colorless, toxic gas. As a product of the photochemical process, it is a major air pollutant.

PARTICULATE - A particle of solid or liquid matter: soot, dust, aerosols, fumes, and mist.

PASQUILL'S STABILITY CATEGORIES - Stability classes as defined by Dr. F. Pasquill of the British Meteorological Service, including extremely unstable , unstable, slightly unstable, neutral, slightly stable, and stable.

PERSISTENCE - Time period over which a certain parameter is maintained.

PHOTOCHEMICAL PROCESS - The chemical changes brought about by the radiant energy of the sun acting upon various polluting substances. The products are known as photochemical smog.

PHYSICAL STACK HEIGHT - Actual height of a stack, i.e., a pollutant source.

PLUME - The volume of air space containing any of the substances emitted from a source. A characteristically-shaped stream of materials or heated gases entering the atmosphere from a localized source such as a stack. A plume may be visible (smoke, water droplets, etc.) or invisible (heated air or colorless gas).

PLUME RISE - The maximum height attained by a plume from vertical momentum and buoyancy due to heat and molecular-weight difference of material released into the atmosphere. Plume behavior is influenced by chimney phenomena, surrounding buildings, terrain, as well as velocity and buoyancy relative to the ambient air.

POLLUTANT - With respect to the atmosphere, any substance discharged into the ambient air tending to create a harmful effect upon man, his property, convenience or happiness, or that causes the contamination in ambient air to exceed legally established limits.

PPM - Parts per million, the number of parts of a given pollutant in a million parts of air; a measure of concentration.

WIND(S) - The wind direction(s) most frequently observed during a given period.

PREVENTION OF SIGNIFICANT DETERIORATION (PSD) - A regulatory program based not on the absolute levels of pollution allowable in the atmosphere but rather on the amount by which present air quality will be allowed to deteriorate in a given area.

RADIATION COOLING - Cooling of the earth's surface and surrounding air accomplished (mainly at night) whenever the earth's surface experiences a net loss of heat.

RADIATIONAL INVERSION - An inversion at the surface due to radiation cooling.

RE-ENTRAINMENT - The mixing of environmental air into an organized air current of which it formerly was a member.

SCREENING LEVEL - A simplistic approach designed to determine the need for additional, more detailed analyses.

SCRUBBER - A device that uses liquid spray to remove aerosol and gaseous pollutants from an airstream. The gases are removed either by absorption or chemical reaction. Solid and liquid particulates are removed through contact with the spray.

SKY COVER - The amount of sky covered or concealed by clouds or other obscuring phenomena.

SLOPE WINDS - Winds caused by uneven surface heating and cooling in areas of rugged terrain.

SMOG - A term coined, originally, to characterize any objectionable, visible combination of smoke and fog. It was soon found, however, that air pollution does not always produce visible smog, nor does fog have to be present when smog is formed. There are two principal types of smog.

PHOTOCHEMICAL (OR LOS ANGELES) SMOG - The smog prevalent in the daytime around sunny, poorly ventilated, heavily motorized urban areas and characterized by the interaction of nitrogen oxides and certain hydrocarbon compounds under the influence of sunlight and, normally in relatively stagnant air. It may reduce visibility, irritate the eyes and damage some vegetation. Automotive exhaust is a prime source of the gases that can produce this form of pollution.

SOLAR ALTITUDE - The elevation angle of the sun above the horizon.

SOLAR INSOLATION - Solar radiation received at the earth's surface.

STABILITY - A measure of the extent to which vertical and horizontal mixing will take place. Commonly measured as unstable, neutral or stable.

STABLE - The lapse rate is less than the dry adiabatic lapse rate and vertical motion is suppressed.

STAR (STABILITY ARRAY) - A description of a type of meteorological program developed by the National Climatic Center in Asheville, North Carolina. The program provides joint frequency distributions of wind speed, wind direction, and atmospheric stability class.

STABILITY WIND ROSES - Diagrams designed to show the distribution of wind direction experienced at a given location over a desired time period for a given atmospheric stability class.

STACK - Any chimney, flue, conduit, or duct arranged to conduct emissions to the outside air.

STATE IMPLEMENTATION PLAN (SIP) - A plan devised by a state and approved by the Administrator of the U.S. EPA for implementing and enforcing provisions of the Clean Air Act. Part of each SIP must describe a PSD program.

SUBSIDENCE INVERSION - A temperature inversion produced by the warming of a layer of descending air. The effect is the creation of a limited mixing volume below the stable layer.

SULFUR OXIDES - Pungent, colorless gases formed primarily by the combustion of fossil fuels; considered major air pollutants, sulfur oxides may damage the respiratory tract as well as vegetation.

SURFACE BASED INVERSION - An inversion layer of stable air close to the ground. Such an inversion inhibits dispersion of fugitive dust and other non-buoyant sources of pollutants.

SURFACE BOUNDARY LAYER - The thin layer of air immediately adjacent to the earth's surface.

SURFACE DATA - Observations of the weather from a point at the surface of the earth, as opposed to upper-air or winds-aloft observations.

SURFACE ROUGHNESS - Irregularities of the earth's surface (provided by trees, buildings, etc.) which increases air turbidity, and in consequently, pollutant dispersion.

SYNOPTIC SCALE WINDS - Strong winds created by weather patterns of high and low pressure systems in the lower troposphere.

TOTAL SUSPENDED PARTICULATE MASS (TSP) - A criteria pollutant measured as the mass of all particles in the atmosphere, without regard to size or chemical composition.

TRAJECTORY - The path followed by a particle in motion.

TRANSPORT - The rate by which a substance or quantity, such as heat, suspended particles, etc., is carried past a fixed point.

TRAPPING - A condition where an effluent diffuses rapidly to the base of an elevated inversion but is prevented from diffusing to greater heights by the stable layer above.

TURBULENCE - A state of fluid flow in which the instantaneous velocities exhibit an irregular pattern and apparently random fluctuations.

TYPICAL CONDITIONS - The most commonly occurring combination of the key dispersion factors - wind speed, wind direction, and atmospheric stability class. Knowledge of the most commnly occurring dispersion conditions provides some indication of the effect of an existing or proposed pollution source.

UNSTABLE - The environmental lapse rate is greater than the dry adiabatic lapse rate and vertical turbulence is enhanced.

UPWIND - The direction from which the wind is blowing.

VALLEY WINDS - A wind which ascends a mountain valley during the day.

VENTILATE - To cause to circulate as in the dispersion of air polutants.

VERTICAL DISPERSION COEFFICIENTS - The vertical standard deviation of plume pollutant concentration. The parameter varies as a function of downwind distance and atmospheric stability.

VIRTUAL SOURCE - The theoretical location of a point source with respect to an actual area source which would result in plume dispersion at the actual point of emission indicative of the area source.

WIND - Air in motion relative to the surface of the earth.

WIND SHEAR - Variation of the wind vector in a given direction.

WINDS ALOFT - Wind speeds and directions at various levels in the atmosphere above the surface.

WORST-CASE CONDITIONS - That combination of wind speed, wind direction and atmospheric stability class that would result in the greatest possible pollutant impact of an existing or proposed source.

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